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A new species of *Eudarcia* subgenus *Abchagleris* and description of the hitherto unknown female of *E.* (*A.*) *sutteri* (Tineidae)

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Summary. A new *Eudarcia* species is described in the subgenus *Abchagleris* along with the hitherto unknown female of *E.* (*A.*) *sutteri* Gaedike, 1997. The new available material makes it possible to extend our knowledge on the biology of *Eudarcia* moths. A study of these two species brought out some more characters of the female genitalia to be synapomorphic for the subgenus *Abchagleris*.

Zusammenfassung. Es wird eine neue *Eudarcia*-Art in der Untergattung *Abchagleris* zusammen mit dem bisher unbekannten Weibchen von *E.* (*A.*) *sutteri* Gaedike, 1997 beschrieben. Das Material ermöglicht es, einige Bemerkungen zur Biologie der Gattung zu machen. Die Untersuchung der Weibchen der beiden Arten erbrachte zusätzliche Merkmale der weiblichen Genitalien, die synapomorph für die Untergattung *Abchagleris* sein können.

Résumé. Une nouvelle espèce d'*Eudarcia* est décrite, appartenant au sous-genre *Abchagleris*, ainsi que la femelle, jusqu'à présent inconnue, de *E.* (*A.*) *sutteri* Gaedike, 1997. Le matériel additionnel à disposition actuellement permet d'approfondir nos connaissances sur la biologie du genre *Eudarcia*. L'étude de ces deux espèces a révélé quelques caractères synapomorphiques additionels du sous-genre *Abchagleris*.

Key words: Lepidoptera, Tineidae, *Eudarcia, Abchagleris*, taxonomy, biology, new species, Crete, Rhodes, Greece.

Shortly after a publication of some remarks on the *Eudarcia* subgenus *Abchagleris* (Gaedike, 1997), along with an attempt to clarify the phylogenetic relationships in this subgenus, it became possible to put forward some additional information based on material from the Greek islands of Crete (Kríti) and Rhodes (Ródos) collected by the second author and G. Verkerk.

Besides of a new species and the hitherto unknown female of another (described below), this material is of certain importance since it also throws some further light on the biology of *Eudarcia* tineid moths.

The holotype and 6 paratypes of the new species are deposited in the collection of the Deutsches Entomologisches Institut, Eberswalde, the rest of the paratypes in the collections of H. Henderickx and G. Verkerk.

Eudarcia (*Abchagleris*) *verkerki* sp. n.

Holotype ♂ (with case and pupal skin), Crete, Mesavía, 700 m, case: 23.III.1997, imago: 19.VI.1997, G. Verkerk & H. Henderickx leg. 15 Paratypes (all cases from the same locality and with the same date): ♂, ♀ (with case and pupal skin), same label data as holotype; 2 ♂, 2 ♀, imago: 20.V.1997; ♂, 2 ♀, imago: 22.V.1997; ♀, imago: 26.V.1997; ♀ (with case and pupal skin), imago: 20.VI.1997; ♂ (with case and pupal skin), imago: 24.VI.1997; 3 ♀ (with case and pupal skin), imago: 2.VII.1997. Additionally, the cases and pupal skins collected on 20. and 22.V.1997 are on separate labels.

Diagnosis (fig. 1). Wingspan 5–8 mm; head yellowish brown, dark grey antennae nearly as long as the forewings, palpi of the same coloration as head, basal segment of maxillar palpi with a brush of long dark bristles; thorax and tegulae dark brownish-grey; forewing of the same coloration as thorax, mixed with a pale yellowish pattern: two broad bands, speckled with dark scales, from costa to posterior wing margin between 1/4 and 1/2, three short strips on the costa before the apex; cilia overlaid with dark scales; hindwings light grey.

Male genitalia (fig. 7, *a-c*). Tegumen without any special structures, with broad rounded upper edge, without developed uncus; a small thin process in the middle of the tegumen directed downwards, two small processes from the lateral edges to the middle; vinculum triangular with deep lateral incisions; corpus valvae nearly cubic, with long transtilla, costal arm long, convex, with rounded tip with many fine bristles, the lower edge of the corpus valvae folded, the tip with two strongly sclerotized short thorns, on the inner side of the corpus with approx. 10 long bristles, which often break off during preparation; aedeagus long, as long as tegumen+vinculum, curved, with a cornutus-like sclerotization and with one cornutus (a short thorn on a broad rounded base).

Female genitalia (fig. 7, *d*). Last abdominal segment strongly sclerotized; the strongest sclerotization around the ostium; ostium and almost entire ductus bursae with strong sclerotization; signum is a field with many very small scale-sized rounded bristles.

Biology (figs. 3, 5, 6). All cases were found in one locality, at the entrance and in the surroundings of a small cave, a crack in a porous rock near Mesavía (Crete, 700 m). The larvae fed on algae or lichens on some longitudinal markings on the wall with greenish appearance. It appeared that a small water source created a convenient humidity and microclimatic conditions, since outside of the cave the rocks were dry and eroded. It is not unlikely that such a small habitat causes a very restricted distribution if not a relict colony. The specimens were bred on parts of the original rock and pupated soon after picking up. Fig. 3 shows mating of the new species under natural conditions, fig. 5, *b* shows the female pupal skin, figs. 6, *a–c* show cases with pupal skins.

Comparative notes. The new species differs in the size of the valva and the tegumen from all other members of the subgenus (*glaseri* (Petersen, 1967); *armata* (Gaedike, 1984); *fasciata* (Staudinger, 1880); *montana* (Gaedike, 1984); *sutteri* Gaedike, 1997). The presence of bristles on the inner side of the corpus valvae is a synapomorphic character shared with *E. sutteri*. The autapomorphic character for separation of the new species from *sutteri* is the size of the valva and the long bristles on the inner side of it. Furthermore the two species differ in female genitalia characters (signum, ductus bursae sclerotization).

The new species is dedicated to Gijs Verkerk, to acknowledge his worthwhile contribution in collecting *Eudarcia*, especially the species described here, and exploring their habitats.

A description of the female of *Eudarcia* (*Abchagleris*) *sutteri* Gaedike, 1997

Material examined. 2 ♀, Rhodes, Apóllona, 600 m, mountain Profítis Ilías, case: 9.–11.V.1997, imago: 15.VI.1997, H. Henderickx & G. Verkerk leg.; ♀, same label data, imago: 4.VI.1997; ♀, Rhodes, Siána, 350 m, case: 10.V.1997, imago: 10.VI.1997, H. Henderickx & G. Verkerk leg.; ♀, Rhodes, Siána, 350 m, in a deep cleft, case: 10.V.1997, imago: 10.VI.1997, H. Henderickx & G. Verkerk leg.

An examination of three female specimens (figs. 2, 4) of *Eudarcia* from Ródos, suggested them to belong to *E.* (*A.*) *sutteri* Gaedike, 1997, a species described on a series of males only.

Recently obtained material makes it possible to describe the female genitalia of this species (fig. 7, *e*): last abdominal segment

Fig. 1. *E. verkerki* sp. n. (Crete, Mesavía, case: 23.III.1997, imago: 19.VI.1997).
Fig. 2. *E. sutteri* (Rhodes, Apóllona, case 9.–11.V.1997, imago 15.VI.1997).
Fig. 3. *E. verkerki* sp. n., mating (Crete, Mesavía, 20.V.1997).
Fig. 4. *E. sutteri* (Rhodes, Apóllona, 4.VI.1997).

strongly sclerotized, ostium with a strongly sclerotized broad ring, which continues as a triangle-shaped sclerotization area in the ductus bursae; signum formed by about 6–8 rows of small sclerotized thorns.

Gijs Verkerk and the second author collected the larvae of this species on shaded humid rocks with mosses and lichens. The localities were situated at an elevation of between 300 and 600 m in a humid pine wood. The species was particularly abundant on the mountain Profítis Ilías near Apóllona, where most specimens were collected in a humid forest with a small river (figs. 5, *b*, 6, *d, e*).

Fig. 5. *Eudarcia*, pupal skin *a* — *E. sutteri* ♀, (Rhodes, Apóllona, case 9 –11.V.1997, imago: 15.VI.1997); *b* — *E. verkerki* sp. n. ♀, (Crete, Mesavía, case: 23.III.1997, imago: 20.VI.1997).

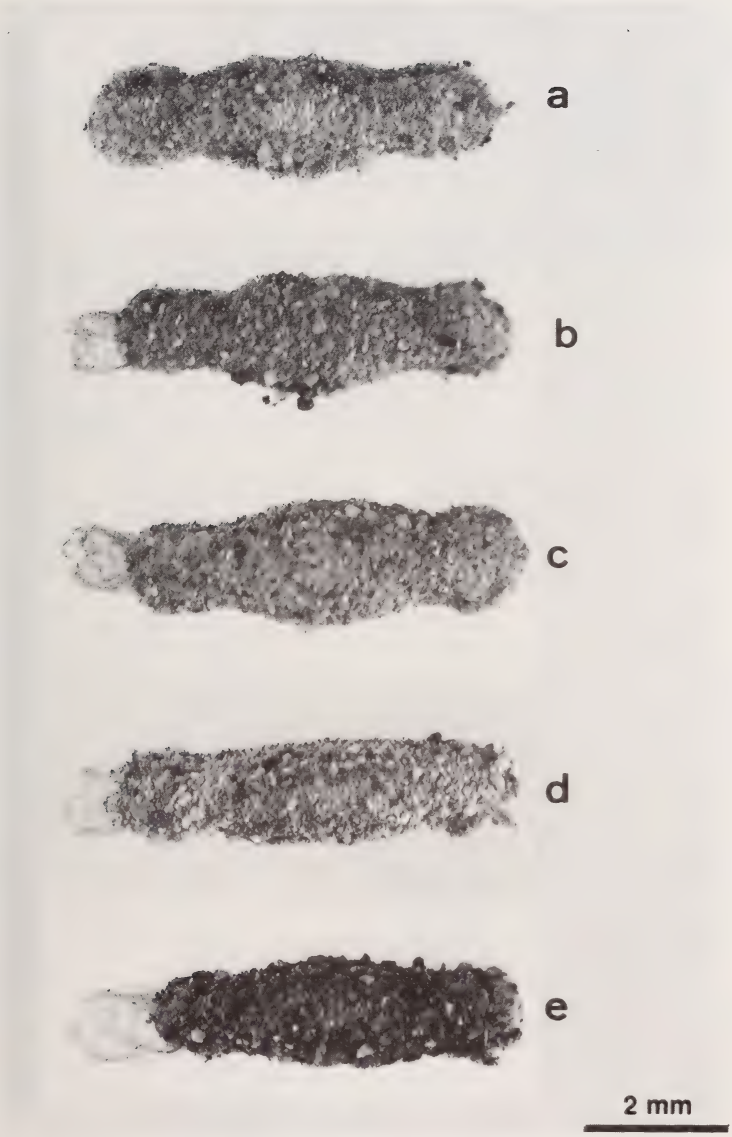

Fig. 6. *Eudarcia*, cases and pupal skin: *a* — *E. verkerki* sp. n. ♂, (Crete, Mesavía, case: 23.III.1997, imago: 20.VI.1997); *b* — *E. verkerki* sp. n., (Crete, Mesavía, case: 23.III.1997, imago: 20.VI.1997); *c* — *E. verkerki* sp. n. ♀, (Crete, Mesavía, case: 23.III.1997, imago: 20.VI.1997); *d* — *E. sutteri* ♀ (Rhodes, Siána, case: 10.V.1997, imago: 10.VI.1997); *e* — *E. sutteri* ♀ (Rhodes, Apóllona, case: 9 –11.V.1997, imago: 15.VI.1997) (*a–c* — cases with pupal skin, *d, e* — pupal skin).

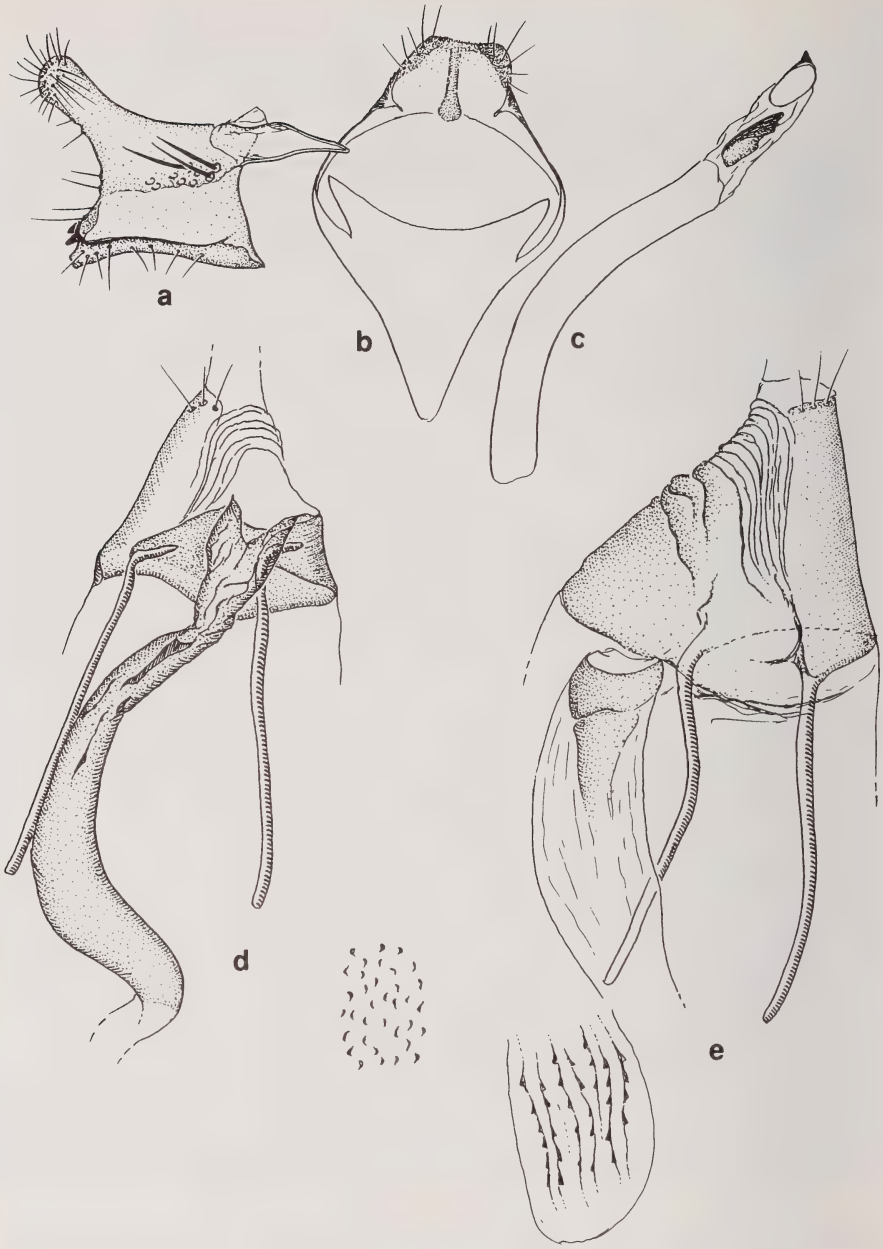

Fig. 7. *Eudarcia*, genitalia: *a–c* — *E. verkerki* sp. n., male genitalia: *a* — valva, *b* — uncus + tegumen + vinculum, *c* — aedeagus (Crete, Mesavía, imago: 20.VI.1997); *d* — *E. verkerki* sp. n., female genitalia (Crete, Mesavía, imago: 22.VI.1997); *e* — *E. sutteri*, female genitalia (Rhodes, Apóllona, imago: 4.VII.1997).

Up to now, the females of three *Abchagleris* species were known. An examination of two out of the forementioned 5 female specimens makes it somewhat more confident to establish phylogenetically founded characters in the female genitalia for this subgenus. It seems that the stronger sclerotization of the last abdominal segment and the signum shape represent synapomorphic characters.

The illustrations on figs. 1–6 were made by the second author, the drawings (fig. 7) by the first author.

Reference

GAEDIKE, R. 1997. Beitrag zur Kenntnis der paläarktischen Tineidae: Gattung *Eudarcia* Clemens, 1860. (Lepidoptera). — *Reichenbachia* 32(17): 99–103, 13 Abb.

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Psychidenbeobachtungen in Westrumänien — Teil 2. Beschreibung von *Siederia transsilvanica* sp. n. (Psychidae)

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Summary. During the spring of 1986, a new species of Psychidae was discovered in the Romanian southern Carpathians that, based on a series of characteristic features, was placed in the genus *Siederia* Meier, 1957. *Siederia transsilvanica* sp. n. is easily distinguishable from the other congeneric species by its wingspan and markings, the relatively low genitalic index and the small size of the case. From the species of the closely related genus *Dahlica* Enderlein, 1912 it is distinguished mainly by the presence of an epiphysis on the foretibia of the male. The new species occurs in shadow-rich rocky places, with abundant growth of algae, lichens and mosses, the foodstuffs of the larvae.

Zusammenfassung. Im Frühjahr 1986 wurde in den rumänischen Südkarpaten eine neue Psychidenart entdeckt, die aufgrund einer Reihe gattungstypischer Merkmale dem Genus *Siederia* Meier, 1957 zugeordnet wurde. *Siederia transsilvanica* sp. n. läßt sich hinsichtlich ihrer Flügelspannweite und Zeichnung, dem relativ niedrigen Genitalindex sowie der Kleinheit der Säcke leicht von den anderen Arten der Gattung trennen. Von den Arten der naheverwandten Gattung *Dahlica* Enderlein, 1912 unterscheidet sie sich in der Hauptsache durch das Vorhandensein einer Epiphyse an den Vordertibien der Männchen. Die neue Art besiedelt schattig gelegene Felsen, an denen reichlich Algen, Flechten und Moose, die Nahrungsquellen der Raupen, vorkommen.

Résumé. Au printemps de 1986, une nouvelle espèce de Psychidae fût découverte en Roumanie, dans les Carpathes méridionales qui, sur base d'une série de caractères typiques, a été placée dans le genre *Siederia* Meier, 1957. *Siederia transsilvanica* sp. n. se distingue aisément des autres espèces du genre par son envergure et ses dessins, l'indice genitalique relativement bas et le fourreau de petite taille. Des espèces du genre apparenté *Dahlica* Enderlein, 1912, il se distingue principalement par la présence d'une epiphyse sur les tibias antérieurs du mâle. La nouvelle espèce se rencontre dans des endroits rocheux ombragés, riches en algues, lichens et mousses, qui constituent la nourriture des chenilles.

Key words: Lepidoptera, Psychidae, *Siederia*, new species, Transsylvania, Romania.

Einleitung

Während der gemeinsamen naturkundlichen Expedition zwischen dem 30.4. und 9.5.1986 haben die Autoren die Psychidenfauna Westrumäniens studiert und die Ergebnisse publiziert (Herrmann & Weidlich, 1990). Damals wurde im Zuge dieser faunistischen Tätigkeiten in den Karpaten eine große Anzahl frisch angesponnener Säcke einer Psychidenart entdeckt, die keiner der bisher aus Rumänien bekannten Taxa zugeordnet werden konnte.

Neuere eingehende taxonomische Untersuchungen bekräftigten die im Fundjahr gefaßte Vermutung, daß es sich hierbei um eine bisher unentdeckt gebliebene Psychidenart handelt, die sich hinsichtlich einer Reihe signifikanter, gattungstypischer Merkmale, wie etwa dem Vorhandensein einer Epiphyse am Vorderbein der Männchen und den breiten Deckschuppen, am besten in den Genus *Siederia* Meier, 1953 eingliedern läßt.

Fundplätze und Biotope

Die neue Art wurde zuerst in der Jiul-Felsschlucht (Südkarpaten) auf einer Distanz von etwa 10 km Länge zwischen Petroşani und Lainici, an sieben engbegrenzten, um 700 m NN hochgelegenen und collin bis submontan geprägten Lokalitäten, in Teilpopulationen nachgewiesen.

Ein weiteres Vorkommen liegt im Bereich von ca. 8 bis 13 km östlich von Petroşani, wo diese Psychidenart in einer engen Kalkschlucht in ca. 600 bis 800 m NN Höhe entdeckt werden konnte.

Mit zum Teil bis zu hundert frisch angesponnenen Säcken trat sie an den meisten Fundstellen in erstaunlich hohen Abundanzen auf. Die Larven siedeln auf offenen, schütter bewachsenen Felsen (metamorphe Gesteine, meist Gneise), wurden aber auch an freien calzitischen Felsbildungen festgestellt. Sämtliche Lebensräume befinden sich in der mit Laubgehölzen reichen Bergwaldstufe, wo Buchen, Hainbuchen, Erlen, Ahorn und Birken dominieren (Abb. 1).

Siederia transsilvanica sp. n.

Holotypus ♂, Rumänien, Südkarpaten, Umg. Petroşani, Jiul-Tal, 700 m NN. 16.–29.5.1986, e. p. leg. R. Herrmann. **Allotypus** ♀, Fundort wie oben. Beide Typen befinden sich im Staatlichen Museum für Naturkunde in Karlsruhe (Deutschland). **Paratypen. 137** ♂: Rumänien, Südkarpaten, Umg. Petroşani, Jiul-Tal, 700 m NN. 16.–29.5.1986, e. p. leg. R. Herrmann. 138 ♂, Fundort wie oben, 15.–25.5.1986, e. l. leg. M. Weidlich. 3 ♂, Rumänien, Südkarpaten, 13 km E Petroşani, 800 m NN. 14.–18.5.1986, e. p. leg. R. Herrmann. 27 ♀, Rumänien, Südkarpaten, Umg. Petroşani, Jiul-Tal, 700 m NN. 16.–29.5.1986, e. p. leg. R. Herrmann. 20 ♀, Fundort wie oben, 08.–23.5.1986, e. p. leg. M. Weidlich. 179 Säcke, Rumänien, Südkarpaten, Umg. Petroşani, Jiul-Tal, 700 m NN. 06.–07.5.1986, leg. R. Herrmann. 246 Säcke, Fundort wie oben, 06.–07.5.1986, leg. M. Weidlich.

Beschreibung

Männchen (Abb. 2). Stirnhaare weißlichgelb, Fühler mit 26 bis 32 Gliedern (einschließlich Scapus und Pedicellus) und sehr langer Bewimperung, die oftmals die Länge eines Geiselgliedes übertrifft. Augen schwarz kreisrund, Nebenaugen fehlen, die meist dreigliederigen Labialpalpen gattungstypisch sehr lang und etwa dem Augendurchmesser entsprechend.

Vorderflügel schmal, nach außen kaum erweitert, mit zugespitztem Apex (gut sichtbar nur bei entschupptem Flügel) und ziemlich geradem Vorderrand.

Flügelspannweite bei 20 untersuchten Tieren 7–11 mm, im Mittel 9 mm.

Die Zeichnung bei den Tieren aus dem Jiul-Tal sehr kontrastreich, mit kleineren und größeren weißlichgelben Flecken, die bei den meisten Exemplaren scharf umgrenzt angelegt sind. Mit deutlich reduzierter Schwarzfärbung hingegen die blassgrau gefärbten Tiere der Kalkschlucht, die insbesondere durch ein starkes Zusammenfließen der hellen Flecken gekennzeichnet sind. Meist ist ein Innenrandfleck gut ausgeprägt vorhanden, seltener dagegen ein Diskoidalfleck.

Im apikalen Teil des Vorderflügels meist 4–6 zackige Deckschuppen der Schuppenklasse V–VI (nach Sauter, 1956).

Aus der Mittelzelle entspringen 9 Adern, wobei m_2 und m_3 meist getrennt verlaufen (20 Flügel untersucht). Nur dreimal entsprangen sie aus einem Punkt. Symmetrische Geäderstrukturen zeigten sich bei 7 Flügelpaaren. Dreimal wurden auch Unterschiede im rechten und linken Flügel festgestellt. So verliefen m_2

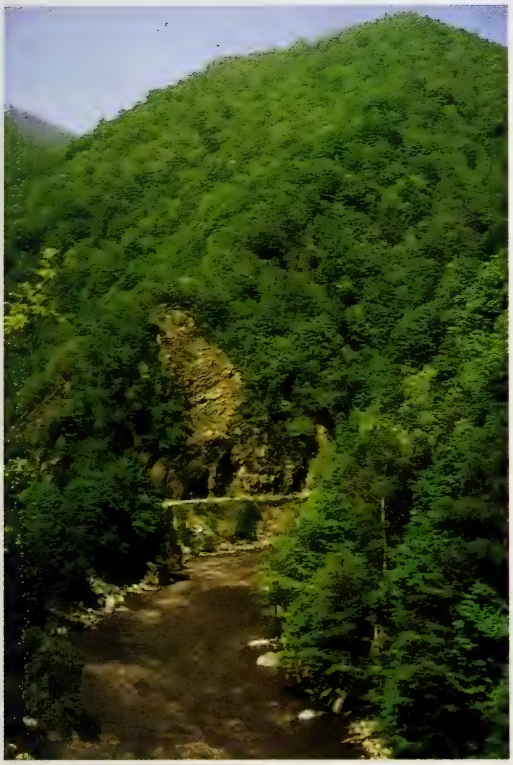

Abb. 1. Felsige waldreiche Steilhänge, wie hier in der Jiul-Felsschlucht südlich von Petroşani, bilden den Lebensraum der neuen Psychidenart.
Foto: R. Herrmann.

Abb. 2. Männchen von *Siederia transsilvanica* sp. n. Durch die markante Fleckung im Vorderflügel und geringe Flügelspannweite kann es leicht von den anderen Arten des Genus unterschieden werden. Foto: R. Herrmann.

und m_3 getrennt bzw. kamen aus einem Punkt. 12 von 20 untersuchten Flügeln hatten eine deutlich erkennbare Anhangzelle (AZ). Nur fünfmal konnte dagegen eine Eingeschobene Zelle (EZ) registriert werden.

Hinterflügel sehr schmal, mit spitzem Apex und einheitlichgrauer Färbung. 6 Adern entspringen aus der Mittelzelle, wobei sie sich bei den 20 kontrollierten Flügeln m_2 und m_3 elfmal kurzgestielt und nur einmal langgestielt zeigten. In acht Fällen entsprangen diese Adern aus einem Punkt. Auch hier m_2 und m_3 bei einigen Faltern im rechten und linken Flügel mit unterschiedlichem Verlauf. Eine Eingeschobene Zelle oft vorhanden! Nur drei der überprüften 20 Flügel hatten keine, stets fehlte indes die Anhangszelle.

Vordertibien mit kleiner Epiphyse, Mitteltibien mit einem, Hintertibien mit zwei Spornpaaren.

Die Genitalstrukturen sind gattungstypisch. Der Genitalindex liegt bei der neuen Art mit Werten zwischen 0,89–1,15 (n = 16) und einem Mittel von 1,02 der Genitalindex (ermittelt nach Sauter, 1956) den Angaben von *S. meierella* (Sieder, 1956) am nächsten. Alle anderen Vertreter der europäischen Arten der Gattung verzeichnen höhere Werte. Messungen an drei präparierten Valven ergaben dazu noch einen Indexwert von 3,444 im Mittel.

Weibchen. Das frischgeschlüpfte flügellose Tier ist hellgrün bis ockergelb gefärbt, hat einen dunkelbraunen chitinisierten Kopf und schwarze Augen. Dunkelbraun sind auch die ersten vier Rückenplatten, heller hingegen die restlichen Tergite und Sternite.

Die schmalen keilförmigen Bauchplatten oft nur gering getrennt oder sich sogar in den Spitzen berührend. Das 7. Sternit dagegen geschlossen und dicht mit cremeweißen Afterwollhaaren überzogen.

Die Fühler mit 13–17 Gliedern, lang und ziemlich frei von Fusionen. Sämtliche Beine mit viergliederigen Tarsen, wobei es an den Vordertibien keine, an den Mittel- und Hintertibien einzelne oder paarig angelegte Endsporne von unterschiedlicher Größe geben kann. Mehrmals fehlten diese Sporne auch vollständig.

Das weibliche Genital mit gattungstypischen Strukturen und ohne große Unterschiede zu den verwandten Arten. Die Kopf-

Brustplatte mit kurzen Fühlerscheiden. Diese lagen bei 19 überprüften Stücken siebenmal knapp unter und viermal leicht über dem distalen Ende der ersten Beinscheiden. Sechsmal hatten sie die gleiche Länge wie die Beinscheiden. Außergewöhnlich lange Fühlerscheiden, vergleichbar etwa denen von *Dahlica nickerli* (Heinemann, 1870) und *D. ticinensis* (Hättenschwiler, 1977), fanden sich dagegen nur bei zwei Exemplaren.

Larven. Die erwachsene Larve ist gelblich. Der Kopf und die ersten beiden Rückenpartien schwarzbraun. Die restlichen Körpersegmente sind beim lebenden Tier graubraun gefärbt.

Säcke. Der meist grau gefärbte Sack ist mit 5,5–6,0 mm recht kurz, ausgeprägt dreikantig, kaum erweitert zur Mitte und deutlich verjüngt bis zu den Enden hin. Er ist mit winzigen Gesteinpartikeln bekleidet und insbesondere an den Kanten oftmals mit feinen grünlichgelben bis weißen Algenbestandteilen bedeckt. So konnten an 164 adulten Säcken, von 216 kontrollierten, Algenreste festgestellt werden. Nennenswerte Geschlechtsunterschiede liegen nicht vor.

Derivatio nominis. Die Namensgebung erfolgt nach den Transsilvanischen Alpen (Südkarpaten). Die Typenlokalitäten befinden sich im westlichen Teil der Südkarpaten, nahe der Industriestadt Petroşani.

Biologie und Ökologie

Mit Hauptzeiten zwischen 6 und 9 Uhr, schlüpften die Männchen, unter Zuchtbedingungen, zwischen 1 Uhr nachts und 12 Uhr. Die Weibchen hingegen zwischen 8 und 12 Uhr sowie in den frühen Abendstunden zwischen 17 und 20 Uhr. Die Lockaktivitäten der Weibchen und die Paarungzeiten fallen überwiegend in die Mittags- und Nachmittagsstunden.

S. transsilvanica sp. n. ist ein typischer Felsenbewohner, deren Entwicklungshabitate schattige und nur zeitweise der Sonne ausgesetzte Stellen mit überwiegend feuchtkühlem Mikroklima sind. Selbst reine Nordseiten werden genutzt, sofern auch hier noch ausreichend Algen, Flechten und Moose als Nahrungsressourcen den Larven zur Verfügung stehen.

Extremstandorte dieser Ausprägung sind artenarm und können von einigen Ubiquisten wie *Taleporia tubulosa* (Retzius, 1783) einmal abgesehen, nur von hoch spezialisierten bzw. stenöken

Arten besiedelt werden. Hierzu wäre neben *S. transsilvanica* sp. n. noch *Dahlica* cf. *wagneri* (Gozmány, 1952) zu nennen, welche im Jiul-Tal syntop vorkommen.

Diskussion

Gegenüber den anderen europäischen Vertretern des Genus *Siederia* läßt sich die neue Art verhältnismäßig einfach abgrenzen.

So ist sie mit einer Flügelspannweite von 7–12 mm auffallend kleiner als *S. alpicolella* (Rebel, 1919) (11,5–14 mm), *S. pineti* (Zeller, 1852) (13–15 mm), *S. meierella* (Sieder, 1956) (13–15 mm) und *S. rupicolella* (Sauter, 1954) (14–15 mm).

Auch durch ihre an Kontrasten reiche Vorderflügel-Fleckung, wie sie in dieser Ausprägung von keiner der nahestehenden Arten erreicht wird, ist *S. transsilvanica* sp. n. schon auf den ersten Blick von diesen Arten verschieden.

Die langen, meist dreigliederigen Labialpalpen der Männchen, der tiefe Genitalindex sowie die kleinen, stark dreikantigen Säcke der neuen Art, bilden eine Reihe weiterer Merkmale, die Artverschiedenheit verdeutlichen.

Zum Vergleich seien die Genitalindizes der europäischen *Siederia*-Arten dargestellt (nach Sauter, 1956; ergänzt durch eigene Angaben):

alpicolella Rebel	1,33–1,48
pineti Zeller	1,19–1,42
meierella Sieder	1,13 (nur ein Wert bekannt)
rupicolella Sauter	1,22–1,37
transsilvanica sp. n.	0,89–1,15.

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The national butterfly recording scheme in Finland: first seven-year period 1991–1997

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Summary. The National Butterfly Recording Scheme in Finland (NAFI) conducted by the South Karelia Allergy and Environment Institute and the Lepidopterological Society of Finland, makes available, for the first time, quantitative information on the butterfly fauna for the whole country. The data, based on the Finnish uniform 27° E grid (10-km squares), numbers of individuals and numbers of observation days, are collected using a uniform questionnaire. During the first seven-year period (1991–1997) a total of 306 voluntary amateur and professional lepidopterists have participated in the scheme, providing data on 889,917 individuals representing all the Finnish resident species (95) and 8 non-resident species. Broadly speaking, the results are in line with earlier knowledge about Finnish butterflies, but not a single threatened or declining species has become more abundant or more widely distributed than was previously assessed. Parallel with this, there were decreases in annual frequencies (see methods) in 8 species, while only one exhibited of increase. As a prospective follow-up study, NAFI provides much needed quantitative on-line knowledge of possible changes in the distribution and abundance of butterflies for attempts to protect the Finnish butterfly fauna.

Zusammenfassung. Das Nationale Tagfalter-Überwachungs-Programm von Finnland (NAFI), gemeinschaftlich durchgeführt vom Südkarelischen Institut für Allergien und Umwelt und der Finnischen Lepidopterologischen Gesellschaft, liefert erstmalig quantitative Informationen zur Tagfalterfauna des ganzen Landes. Die Daten (Anzahl beobachteter Individuen bzw. Anzahl von Nachweisen pro Tag) werden auf der Kartierungsgrundlage des einheitlichen Finnischen Quadrantensystems (in 10-km^2-Feldern) gesammelt. Während der ersten Siebenjahresperiode (1991–1997) haben 306 Lepidopterologen (Amateure und Berufsentomologen) insgesamt Daten zu 889,917 beobachteten Individuen geliefert, die alle 95 in Finnland heimischen sowie 8 nicht dauerhaft residente Arten repräsentieren. Insgesamt bestätigt dieser Datensatz bisherige Einschätzungen zur finnischen Tagfalterfauna. Keine einzige gefährdete oder bestandsrückläufige Art stellte sich demnach als häufiger oder weiter verbreitet heraus als zuvor angenommen. Acht weitere Arten scheinen in ihrer jährlichen Häufigkeit rückläufig zu sein (siehe "Methoden"), während nur bei einer Art Hinweise auf positive Bestandsentwicklung auftraten. NAFI stellt dringend benötigte quantitative Informationen in Zukunft auch on-line zur Verfügung, um mögliche Änderungen in der Verbreitung und Häufigkeit der finnischen Tagfalterfauna überwachen und Maßnahmen zum Schutz einleiten zu können.

Résumé. Le Programme National d'Inventarisation des Papillons Diurnes de Finlande (NAFI), conduit par l'Institut d'Allergie et de l'Environement de Carélie du Sud et la Société Lépidoptérologique de Finlande, rend disponible, pour la première fois, de l'information quantitative sur la faune des papillons diurnes du pays entier. Les données, basées sur le système de coordonnées 27° E finlandais uniformisé (carroyage 10 × 10 km), les nombres d'individus et les nombres de jours d'observation, sont assemblées au moyen d'un questionnaire uniforme. Durant la première période de sept ans (1991–1997), au total 306 lépidoptéristes volontaires, amateurs et professionnels, ont participé à l'inventarisation, fournissant des données sur quelques 889,917 spécimens représentant toutes les espèces autochtones (95) et 8 espèces non-résidentes. En règle générale, les résultats s'inscrivent dans la lignée de nos connaissances antérieures sur les papillons diurnes de Finlande, mais aucune espèce menacée ou en régression est devenue plus commune ou plus répandue qu'il n'était précédemment établi. Parallèlement à cela, il y eût une décroissance en fréquences annuelles (voir méthodes) chez 8 espèces, alors que seulement une seule espèce montrait un acroissement. En tant qu'étude prospective à poursuivre, NAFI fournit des données quantitatives actualisées sur des changements possibles affectant la distribution et l'abondance de papillons diurnes, d'une grande nécessité dans le cadre d'efforts de protection de la faune des papillons diurnes de Finlande.

Key words: Lepidoptera, butterflies, fauna, monitoring, Finland.

Introduction

There are 114 butterfly species found in Finland. The fauna comprises 95 resident species, 14 of which live in Lapland in northernmost Finland (Marttila *et al.*, 1991).

Over the last few decades the decline of butterflies has been a general phenomenon in the country. One species has become extinct, four are endangered and six are considered vulnerable. Furthermore, there are 15 declining, insufficiently known and rare species in need of monitoring, making a total of 26 threatened butterfly species in Finland (Rassi *et al.*, 1992, Somerma, 1997). In addition, Marttila *et al.* (1991) evaluated that the status of another 15 species has been adversely affected during the last 20 years. Altogether, this makes 41 species that are declining, amounting to 43% of all the indigenous butterflies in Finland. At the same time only 8 species (8%) have become more abundant.

Decline of butterflies is mainly caused by changes in agricultural practices, the loss of meadows through the cessation of hay cutting and cattle grazing, indirect nitrogen fertilization of meadows by air pollution, heavy use of pesticides, herbicides and

fertilizers, a strong decline in natural pastures, the centralization of production, and depopulation of the countryside. The other main reason for the decline is changes in forestry, especially the drainage of peatlands and reforestation of open habitats (Marttila *et al.*, 1991, Rassi *et al.*, 1992, Väisänen, 1992, Somerma, 1997).

In spite of the alarming trends in the butterfly fauna of Finland, no permanent or large-scale follow-ups, based on quantitative data, have been carried out in the country. On the whole, there are only a few European countries where national monitoring of butterflies has been established. In Great Britain (Pollard *et al.*, 1986, Pollard & Yates, 1993) and The Netherlands (van Swaay *et al.*, 1997, van Strien *et al.*, 1997), the schemes are carried out using a network of transect counts. In Denmark, the monitoring scheme is based on observations by volunteers with transect counts and free observations (Stoltze, 1996), but today the scheme is continuing on a much smaller scale than previously (Peder Skou, pers. comm.).

In Finland, knowledge of population changes in butterflies has mostly been based on long-term collecting in the same locality, combined with thorough records, and surveys with queries and literature reviews. As a consequence, changes in the occurrence and abundance of butterflies, especially of common and non-threatened species, have been poorly known. The need for continuous countrywide butterfly monitoring has been obvious.

The South Karelia Allergy and Environment Institute and the Lepidopterological Society of Finland in 1991 organised a countrywide follow-up study, the National Butterfly Recording Scheme in Finland (NAFI), which is intended to create quantitative on-line knowledge for the attempts to monitor changes in the distribution and abundance of butterflies in Finland. We report here the methods and some results of the scheme application.

Methods

The monitoring scheme is directed to all voluntary amateur and professional lepidopterists and also naturalists interested in butterflies. All participants recorded their yearly observations on the form designed for the scheme. The data on each form includes the year, the Finnish uniform 27° E grid (10 km square), the

number of counted or estimated individuals of species observed, and the number of counted or estimated observation days. No advice on the use of zero, i.e. negative observation of species, is given. The recorder's name and address are also requested for correspondence purposes.

Forms are distributed by the Lepidopterological Society and South Karelia Allergy and Environment Institute. New forms and a franked, addressed envelope are mailed every April to the most active and other potential participants. Participants who are not members of the Society have also received a reprint of the previous year's survey results. Forms returned before the end of November have been included in the annual survey published in the *Bulletin of the Lepidopterological Society (Baptria)* (Marttila, 1992, 1993, 1994, Marttila & Saarinen, 1995, 1996a, 1997, Saarinen & Marttila, 1998). Forms mailed after the deadline were not ignored but retained for comparison in the next season's survey.

The forms are transformed and fed into a computer program designed for NAFI. The main tools of the program, which are needed on every form, are the 10 km square, the individual number of species observed, and the number of observation days. The data on each form is checked carefully. If necessary, questionable observations are verified by contacting the observer. Several checks have been made yearly, and assistance has also been given with filling in the form. Finally the computer data are read carefully and verified by a random selection of 5–10% of the new files. The data are collected and stored at the South Karelia Allergy and Environment Institute.

The program prints out the processed numerical data on each species as distribution maps. There are three kinds of maps. All of these show the result in terms of the 10 km squares: (1) *The accumulative map* of species shows the accumulative data for all years, (2) *The average map* shows the accumulative data as averages of certain years, and (3) *The relative map* shows the number of individuals related to observation days: [$(\Sigma n)/d$, where n is the number of individuals observed in any of 10 km square on any day and d is the number of days], being either accumulative or the average of certain years.

In many cases this map reveals the regional differences in abundance better than the total numbers of individuals.

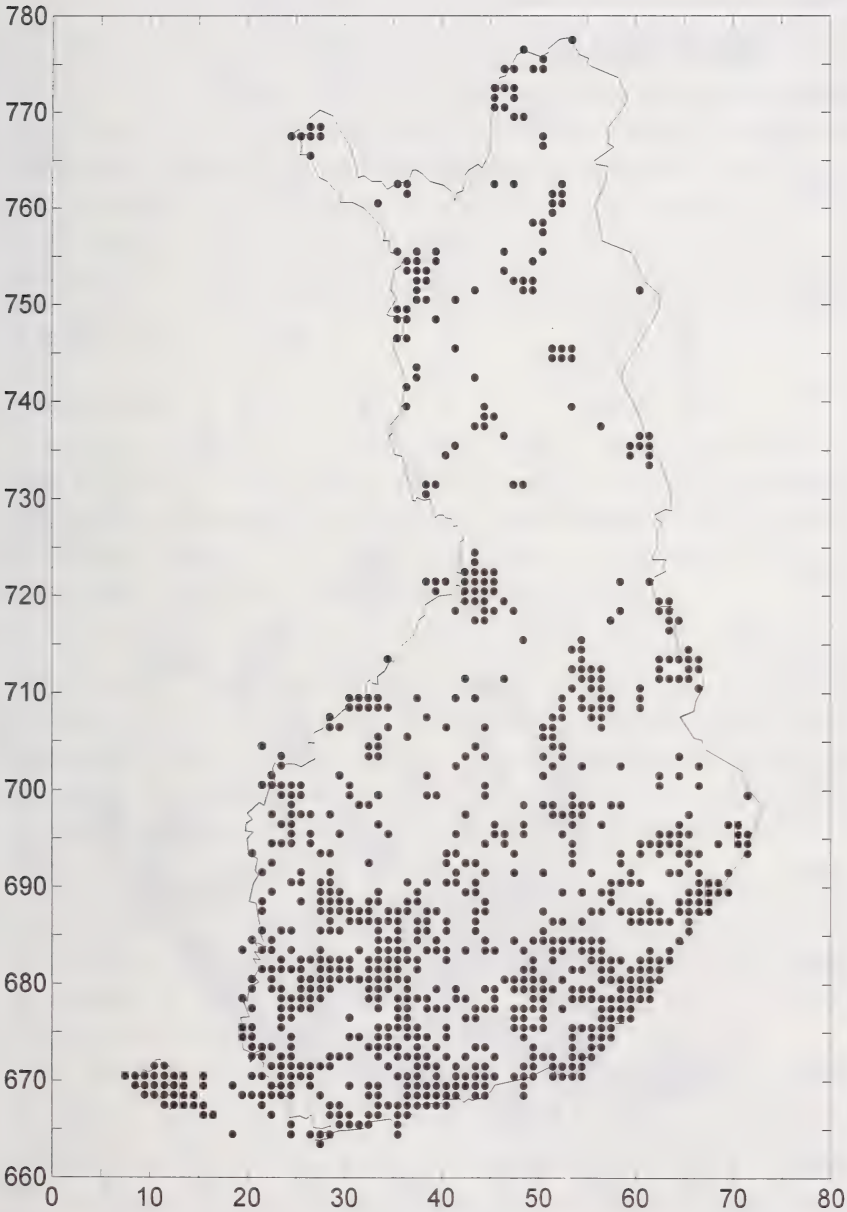


Fig. 1. The network of the National Butterfly Recording Scheme in Finland over the first seven-year period (1991–1997). The total number of positive 10 km squares (Finnish uniform 27° E grid) was 891.

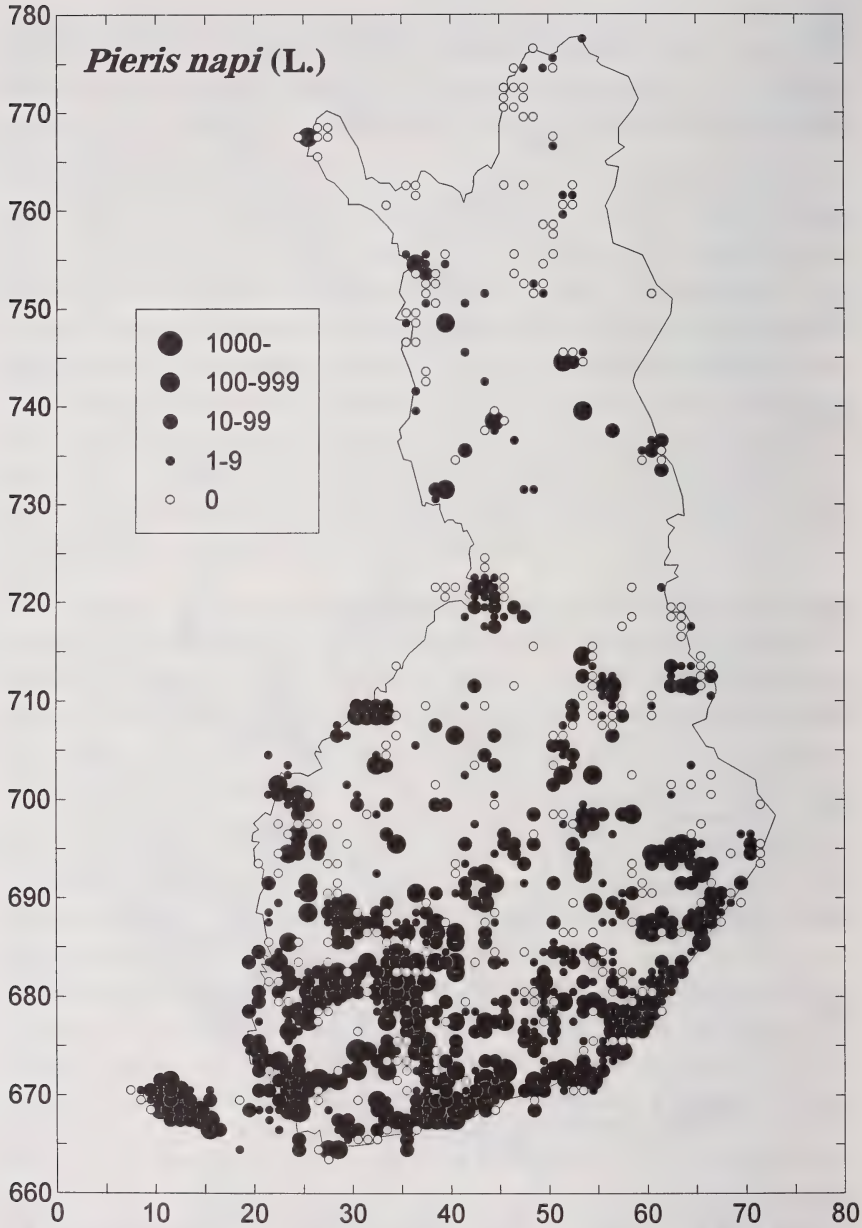


Fig. 2. The accumulative map of *Pieris napi* based on data from the first seven-year period (1991–1997). The species was the most numerous in the recording scheme during the period. The total number of individuals in each positive 10 km square is illustrated using proportionally-sized symbols.

The annual variation in the numbers of participants and observation days leads to the dilemma that a direct comparison of individual numbers of species between years is not really valid. To avoid this problem we have calculated annual frequencies for each species by dividing the positive 10 km squares (at least one individual observed) by the total number of squares in each year. For example, if the species is present in 250 squares and the total number of squares is 500, the frequency is 50%. To distinguish any trend in annual frequencies of the species during the seven-year period we used the linear regression (e.g. Sokal & Rohlf, 1981).

Some results

Altogether 306 persons have taken part in the scheme between 1991 and 1997. The seven-year data consists of 103 species and almost 890,000 butterfly individuals (Table 1 and 2). Fig. 1 depicts the NAFI network. In Figs. 2–4 there are examples of both accumulative and relative maps of certain species.

The proportion of the five most abundant species, *Pieris napi* (75,636 individuals), *Gonepteryx rhamni* (59,497), *Callophrys rubi* (56,506), *Aglais urticae* (55,467) and *Aphantopus hyperantus* (54,783), amounted to more than one third (34%) of all individuals. The most abundant migrant was *Vanessa atalanta* (7,986), and the most substantial migration events during the period were observed with *V. atalanta* (6,028) and *Vanessa cardui* (3,426) in 1994 and 1996, respectively (Table 2).

The year 1995 was the most favourable for butterflies. The total numbers of individuals on one average observation day for the whole country were as follows: 16 (1991), 28 (1992), 26 (1993), 26 (1994), 47 (1995), 28 (1996) and 23 (1997), the average of the whole seven-year period being 28 individuals in a day.

In terms of annual frequencies during the period there were increases in *Aricia nicias* ($r = 0.915^{**}$) and decreases in following 8 species: *Colias palaeno* ($r = -0.81^{*}$), *Lycaena hippothoe* ($r = -0.87^{*}$), *Boloria aquilonaris* ($r = -0.809^{*}$), *Euphydryas maturna* ($r = -0.796^{*}$), *Euphydryas aurinia* ($r = -0.895^{**}$), *Oeneis jutta* ($r = -0.998^{*}$), *Coenonympha pamphilus* ($r = -0.910^{**}$) and *C. tullia* ($r = -0.842^{*}$) (Table 2). Note that a periodical species *O. jutta* is in flight only in even years and the records available for the analysis were only of three years.

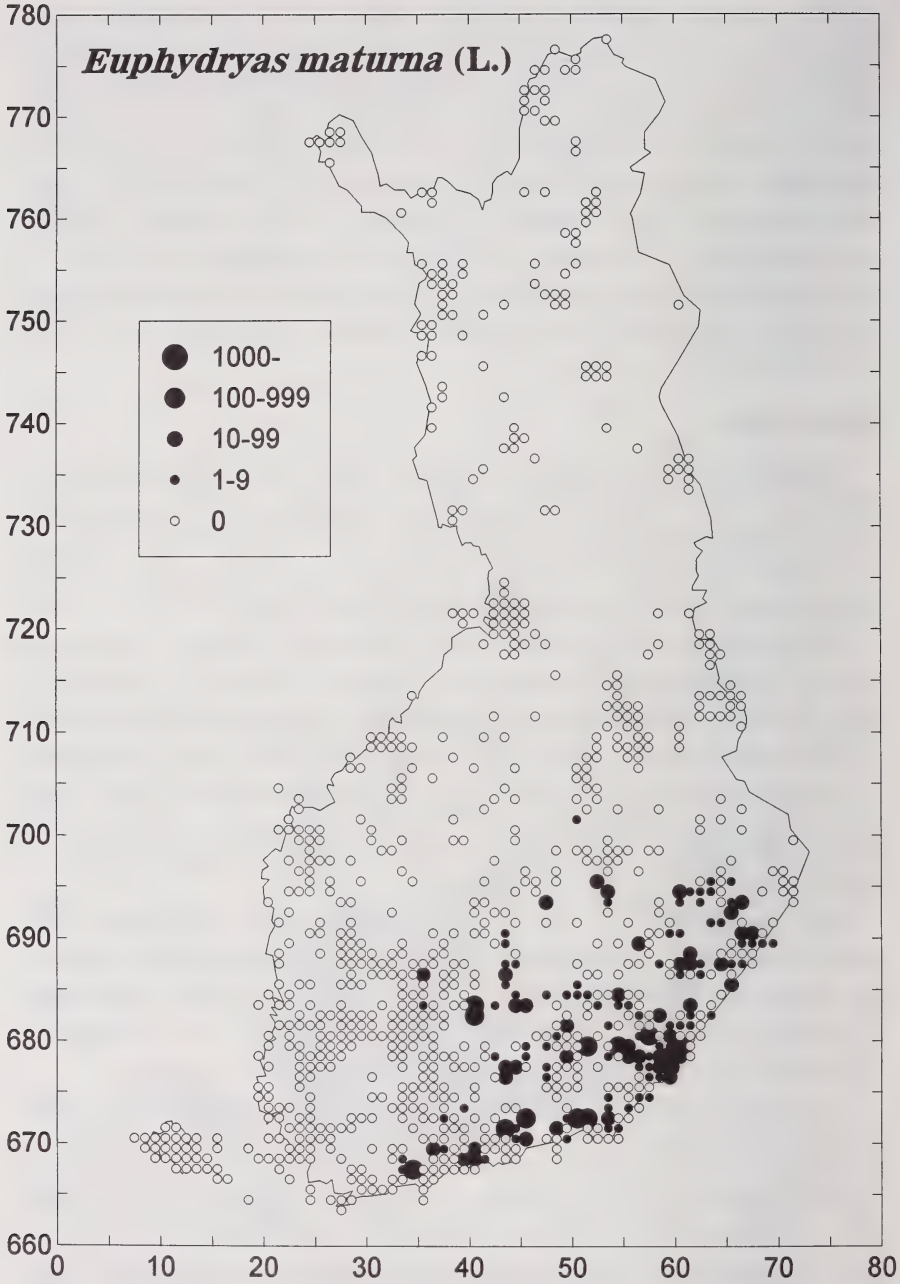


Fig. 3. The accumulative map of *Euphydryas maturna*. The map based on data from the first seven-year period (1991–1997) is an example of a species having a restricted distribution in the country. The total number of individuals in each positive 10 km square is illustrated using proportionally-sized symbols.

Table 1. The basic statistics of the National Butterfly Recording Scheme in Finland during the first seven-year period 1991–1997.

	1991	1992	1993	1994	1995	1996	1997	Total
Participants	42	90	117	151	168	176	168	306
Forms	91	255	338	565	610	571	521	2,951
10 km squares	79	204	259	376	401	433	418	891
Observation days	1,558	3,119	3,784	4,994	5,596	6,115	5,121	30,287
Species	71	83	96	98	96	96	93	103
Individuals	24,559	87,977	98,640	127,164	262,158	170,743	118,676	889,917

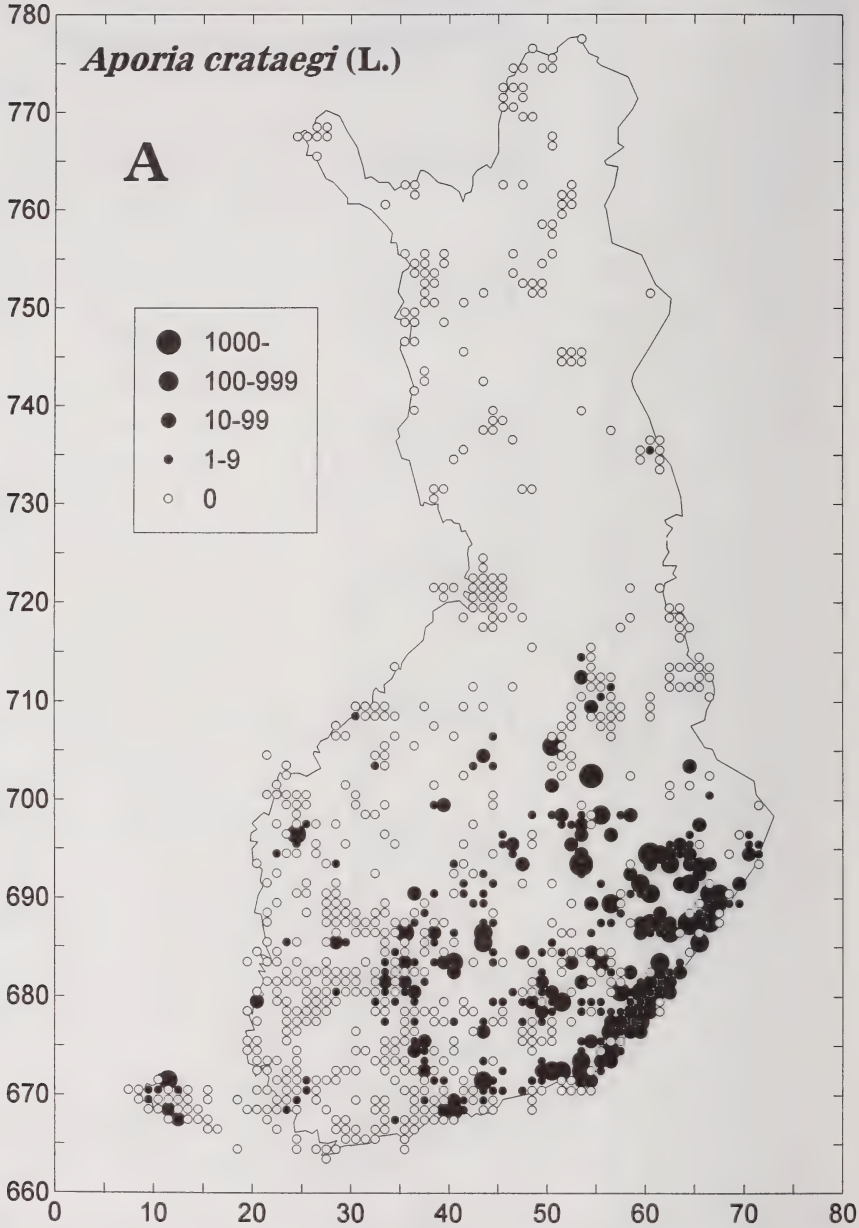
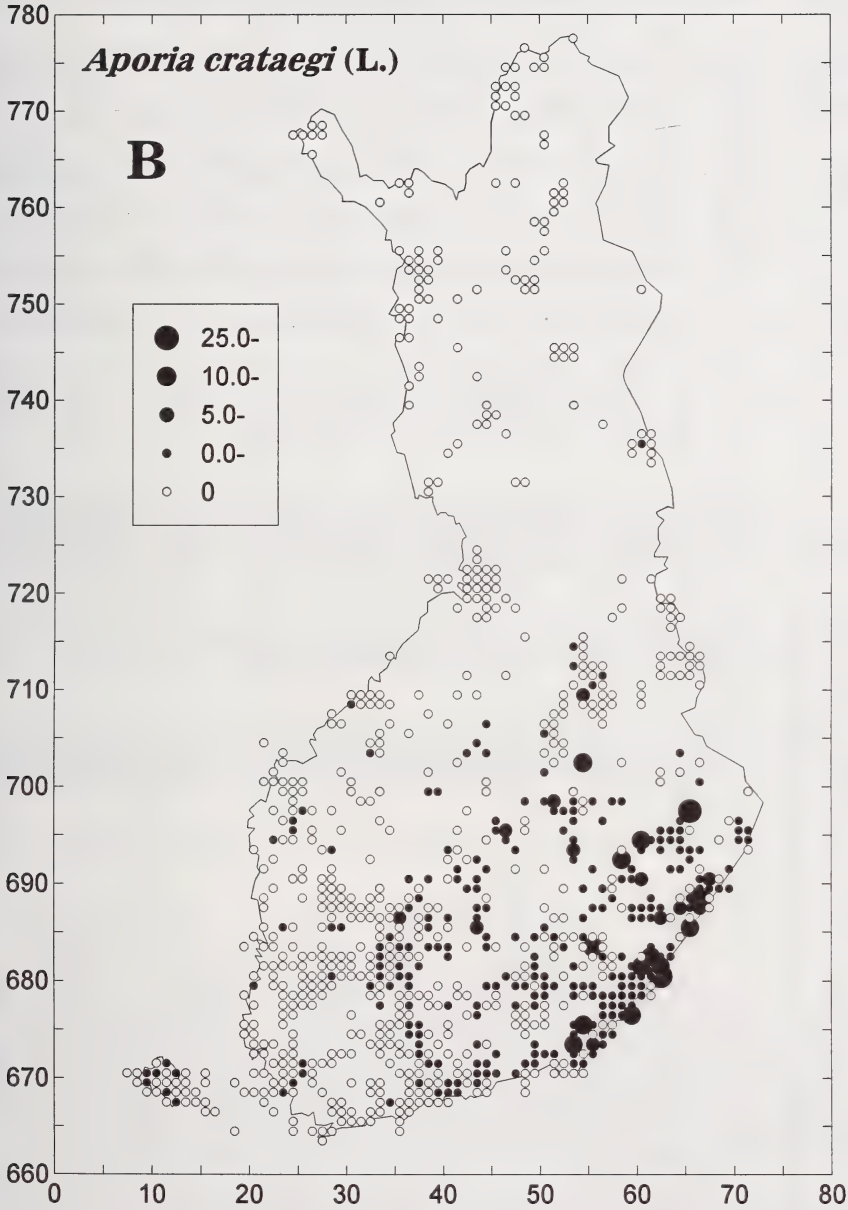


Fig. 4. The accumulative (A) and relative map (B) of *Aporia crataegi* based on data from the first seven-year period (1991–1997). The relative map shows the regional difference in abundance better than the accumulative map. On the accumulative map the total number of individuals in each positive 10 km square is illustrated using



proportionally-sized symbols, while on the relative map the spot shows the number of individuals [$(\Sigma n)/d$, where n is the number of individuals observed in any 10 km square on any day and d is the number of days].

Table 2. The comprehensive list of butterflies found in Finland and the numbers of individuals in the National Butterfly Recording Scheme in Finland during the first seven-year period 1991–1997. The nomenclature follows the checklist of Karsholt & Razowski (1996) with some minor amendments. Non-resident species are marked with an asterisk (*). For annual frequencies (%), see under **Methods** and **Some results**.

	Species	NUMBER OF INDIVIDUALS				FREQUENCY (%) 1991–1997						
		total	average	maximum	minimum							
1.	*Pyrgus andromedae* (Wallengren, 1853)	37	5	10 (94)	0	0	0	< 1	< 1	< 1	< 1	< 1
2.	*P. centaureae* (Rambur, [1839])	249	36	58 (94)	23 (92)	3	4	2	4	2	3	1
3.	*P. malvae* (Linnaeus, 1758)	4,026	575	1,517 (96)	259 (94)	30	26	25	15	20	28	17
4.	*P. alveus* (Hübner, [1803])	420	60	98 (92)	5 (91)	5	10	7	3	6	4	5
5.	**Heteropterus morpheus* (Pallas, 1771)	0	0	0	0	0	0	0	0	0	0	0
6.	*Carterocephalus palaemon* (Pallas, 1771)	990	141	197 (95)	45 (91)	10	10	10	4	6	5	9
7.	*C. silvicola* (Meigen, 1829)	3,661	523	825 (96)	210 (91)	32	38	40	17	21	26	23
8.	*Thymelicus lineola* (Ochsenheimer, 1808)	49,889	7,127	16,975 (95)	1,335 (91)	51	58	51	44	55	49	52
9.	*Hesperia comma* (Linnaeus, 1758)	208	30	56 (96)	7 (91)	4	2	3	2	1	1	2
10.	*Ochlodes venata* (Bremer & Gray, 1853)	16,424	2,346	4,569 (96)	662 (91)	58	53	45	31	45	48	41
11.	*Parnassius mnemosyne* (Linnaeus, 1758)	260	37	66 (93)	0	3	0	2	1	1	1	1
12.	*P. apollo* (Linnaeus, 1758)	678	97	233 (96)	0	0	2	1	1	2	2	1
13.	**Iphiclides podalirius* (Linnaeus, 1758)	0	0	0	0	0	0	0	0	0	0	0
14.	*Papilio machaon* (Linnaeus, 1758)	2,001	286	616 (96)	39 (91)	27	34	34	16	34	34	26
15.	*Leptidea sinapis* (Linnaeus, 1758)	10,519	1,503	2,798 (96)	320 (91)	44	48	45	34	38	42	39
16.	*Anthocharis cardamines* (Linnaeus, 1758)	12,923	1,846	3,660 (95)	532 (91)	49	53	49	35	49	47	29
17.	*Aporia crataegi* (Linnaeus, 1758)	21,332	3,047	11,046 (95)	129 (91)	28	37	22	16	31	23	23
18.	**Pieris brassicae* (Linnaeus, 1758)	3,677	525	2,462 (95)	73 (91)	18	28	19	7	37	15	11
19.	**P. rapae* (Linnaeus, 1758)	3,203	458	1,226 (92)	22 (91)	10	32	21	6	18	11	11
20.	*P. napi* (Linnaeus, 1758)	75,636	10,805	21,656 (95)	2,275 (91)	68	74	73	67	78	67	69
21.	**Pontia daplidice* (Linnaeus, 1758)	151	22	151 (95)	0	0	0	0	0	4	0	0
22.	**P. chloridice* (Hübner, [1813])	0	0	0	0	0	0	0	0	0	0	0
23.	*Colias nastes* (Boisduval, 1832)	70	10	45 (94)	0	0	0	< 1	< 1	< 1	< 1	0
24.	*C. palaeno* (Linnaeus, 1761)	5,726	818	1,777 (92)	196 (91)	34	49	38	25	33	20	14
25.	**C. croceus* (Fourcroy, 1785)	0	0	0	0	0	0	0	0	0	0	0
26.	*C. hecla* (Lefebvre, 1836)	253	36	155 (94)	0	0	0	1	1	< 1	0	1
27.	**C. hyale* (Linnaeus, 1758)	154	22	129 (95)	0	0	2	0	< 1	4	1	0
28.	*Gonepteryx rhamni* (Linnaeus, 1758)	59,497	8,490	17,608 (95)	1,602 (91)	67	62	61	50	62	61	56
29.	*Lycaena phlaeas* (Linnaeus, 1761)	2,870	410	674 (95)	118 (91)	28	24	23	27	28	25	21
30.	*L. helle* ([Denis & Schiffermüller], 1775)	46	7	27 (95)	0	0	1	< 1	< 1	< 1	< 1	< 1
31.	*L. dispar* ([Haworth], 1802)	6	1	5 (97)	0	0	0	0	0	0	< 1	< 1
32.	*L. virgaureae* (Linnaeus, 1758)	27,444	3,921	7,155 (95)	572 (91)	57	55	53	47	54	46	54

33.	*L. hippothoe* (Linnaeus, 1761)	2,697	385	804 (95)	94 (91)	34	23	21	18	22	16	13
34.	*Thecla betulae* (Linnaeus, 1758)	393	56	86 (95)	3 (91)	1	4	3	1	3	2	2
35.	*Neozephyrus quercus* (Linnaeus, 1758)	438	63	162 (95)	0	0	2	2	1	2	2	2
36.	*Callophrys rubi* (Linnaeus, 1758)	56,506	8,072	18,512 (96)	753 (91)	54	54	63	51	63	60	49
37.	*Satyrium w-album* (Knoch, 1782)	109	16	68 (96)	0	0	< 1	2	1	0	< 1	1
38.	*S. pruni* (Linnaeus, 1758)	398	57	159 (95)	19 (91)	9	8	4	3	4	3	3
39.	*Cupido minimus* (Fuessly, 1775)	750	107	396 (95)	0	1	0	2	1	1	1	1
40.	**C. argiades* (Pallas, 1771)	0	0	0	0	0	0	0	0	0	0	0
41.	*Celastrina argiolus* (Linnaeus, 1758)	11,869	1,696	5,494 (96)	59 (91)	27	30	45	36	43	51	37
42.	*Pseudophilotes vicrama* (Moore, 1865)	178	25	71 (94)	0	0	0	< 1	1	< 1	< 1	1
43.	*Scolitantides orion* (Pallas, 1771)	151	22	44 (95)	3 (93)	3	1	1	1	1	1	< 1
44.	*Glaucopsyche alexis* (Poda, 1761)	308	44	129 (95)	4 (91)	5	4	3	1	4	4	1
45.	*Maculinea arion* (Linnaeus, 1758)	77	11	24 (92)	0	0	1	1	< 1	1	1	0
46.	*Plebeius argus* (Linnaeus, 1758)	35,127	5,018	12,339 (95)	588 (91)	37	43	40	35	43	35	36
47.	*P. idas* (Linnaeus, 1761)	17,137	2,448	7,126 (95)	206 (91)	24	33	23	32	36	27	33
48.	*P. optilete* (Knoch, 1781)	10,217	1,460	2,471 (95)	322 (91)	32	43	32	34	32	31	36
49.	*P. glandon* (Prunner, 1798)	31	4	20 (96)	0	0	0	< 1	0	0	< 1	< 1
50.	*Aricia eumedon* (Esper, 1780)	7,760	1,109	2,653 (95)	73 (91)	15	20	23	20	23	18	15
51.	*A. artaxerxes* (Fabricius, 1793)	2,055	294	546 (95)	33 (91)	14	18	14	13	17	13	13
52.	*A. nicias* (Meigen, 1830)	2,236	319	1,214 (97)	0	0	2	2	3	4	3	5
53.	*Polyommatus semiargus* (Rottemburg, 1775)	9,289	1,327	2,468 (95)	338 (91)	43	51	36	26	39	33	35
54.	*P. amandus* (Schneider, 1792)	15,569	2,224	4,183 (95)	270 (91)	34	49	42	35	41	40	41
55.	*P. icarus* (Rottemburg, 1775)	7,963	1,138	2,203 (95)	338 (91)	28	37	29	27	34	32	33
56.	*Argynnis paphia* (Linnaeus, 1758)	2,409	344	983 (95)	48 (91)	5	5	5	4	5	5	5
57.	*A. aglaja* (Linnaeus, 1758)	15,140	2,163	6,210 (95)	246 (91)	38	50	37	37	48	36	38
58.	*A. adippe* ([Denis & Schiffermüller], 1775)	15,011	2,144	6,741 (95)	93 (91)	20	41	35	34	43	27	27
59.	*A. niobe* (Linnaeus, 1758)	1,992	285	665 (95)	17 (91)	4	10	9	8	11	6	6
60.	**A. laodice* (Pallas, 1771)	1	0	1 (94)	0	0	0	0	< 1	0	0	0
61.	*Issoria lathonia* (Linnaeus, 1758)	519	74	237 (95)	1 (97)	1	2	4	3	4	2	< 1
62.	*Brenthis ino* (Rottemburg, 1775)	28,268	4,038	11,762 (95)	372 (91)	43	54	45	42	52	43	44
63.	*Boloria eunomia* (Esper, [1799])	6,817	974	1,509 (96)	141 (91)	17	23	22	21	18	19	16
64.	*B. euphrosyne* (Linnaeus, 1758)	24,390	3,484	6,209 (96)	771 (91)	54	55	58	48	47	46	41
65.	*B. titania* (Esper, [1793])	1,016	145	336 (95)	0	0	2	1	< 1	1	1	1
66.	*B. selene* ([Denis & Schiffermüller], 1775)	25,045	3,578	6,469 (95)	691 (91)	54	57	51	42	51	49	45
67.	*B. chariclea* (Schneider, 1794)	433	62	314 (97)	0	0	0	< 1	1	1	0	2
68.	*B. freija* (Thunberg, 1791)	1,342	192	306 (96)	18 (91)	6	5	10	7	8	8	8
69.	*B. polaris* (Boisduval, 1828)	72	10	19 (97)	0	0	0	< 1	< 1	1	< 1	1
70.	*B. thore* (Hübner, [1803])	255	36	125 (95)	0	0	1	1	1	1	1	1
71.	*B. frigga* (Thunberg, 1791)	1,018	145	294 (92)	3 (91)	4	7	5	6	4	5	4
72.	*B. improba* (Butler, 1877)	12	2	12 (94)	0	0	0	0	< 1	0	0	0
73.	*B. napaea* (Hoffmansegg, 1804)	27	4	14 (94)	0	0	0	0	1	0	< 1	1
74.	*B. aquilonaris* (Stichel, 1908)	5,341	763	1,280 (95)	140 (91)	19	25	21	19	18	15	13
75.	**Vanessa atalanta* (Linnaeus, 1758)	7,986	1,141	6,028 (94)	25 (93)	19	22	4	31	32	22	9
76.	**V. cardui* (Linnaeus, 1758)	5,062	723	3,426 (96)	16 (97)	28	18	4	4	37	56	2

	Species	NUMBER OF INDIVIDUALS				FREQUENCY (%) 1991–1997						
		total	average	maximum	minimum							
77.	*Inachis io* (Linnaeus, 1758)	12,247	1,750	3,598 (95)	442 (91)	30	35	26	25	28	31	23
78.	*Aglais urticae* (Linnaeus, 1758)	55,467	7,924	20,516 (95)	1,660 (91)	72	67	62	61	68	63	44
79.	*Polygonia c-album* (Linnaeus, 1758)	12,173	1,739	3,233 (95)	167 (91)	42	46	46	36	46	44	38
80.	*Araschnia levana* (Linnaeus, 1758)	401	57	146 (97)	0	0	2	1	1	1	1	2
81.	*Nymphalis antiopa* (Linnaeus, 1758)	10,254	1,465	2,364 (97)	263 (91)	52	51	52	38	49	45	48
82.	**N. polychloros* (Linnaeus, 1758)	1	< 1	1 (95)	0	0	0	0	0	< 1	0	0
83.	**N. xanthomelas* (Esper, [1781])	0	0	0	0	0	0	0	0	0	0	0
84.	**N. vaualbum* ([Denis&Schiffermüller], 1775)	0	0	0	0	0	0	0	0	0	0	0
85.	*Euphydryas iduna* (Dalman, 1816)	15	2	6 (96)	0	0	0	1	1	< 1	1	< 1
86.	*E. maturna* (Linnaeus, 1758)	4,135	591	924 (96)	260 (91)	22	16	17	11	14	10	13
87.	*E. aurinia* (Rottemburg, 1775)	1,183	169	418 (96)	33 (92)	3	2	2	2	2	1	1
88.	*Melitaea cinxia* (Linnaeus, 1758)	4,047	578	1745 (91)	3 (97)	3	1	1	2	2	3	< 1
89.	*M. diamina* (Lang, 1789)	1,742	249	937 (95)	1 (91)	1	1	1	1	2	1	1
90.	*M. athalia* (Rottemburg, 1775)	11,129	1,590	4,342 (96)	347 (91)	38	37	38	23	32	37	30
91.	*Limenitis populi* (Linnaeus, 1758)	1,170	167	738 (95)	23 (94)	11	16	8	4	14	6	6
92.	*Apatura iris* (Linnaeus, 1758)	93	13	80 (96)	0	0	0	< 1	0	0	< 1	< 1
93.	*Pararge aegeria* (Linnaeus, 1758)	3,646	521	1,196 (96)	79 (91)	18	19	22	12	16	19	14
94.	**Lasiommata megera* (Linnaeus, 1767)	0	0	0	0	0	0	0	0	0	0	0
95.	*L. petropolitana* (Fabricius, 1787)	7,590	1,084	2,340 (96)	197 (91)	32	29	32	24	29	31	29
96.	*L. maera* (Linnaeus, 1758)	21,923	3,132	6,587 (95)	797 (91)	43	53	46	36	47	42	34
97.	*Lopinga achine* (Scopoli, 1763)	150	21	50 (94)	0	0	1	1	< 1	< 1	1	0
98.	*Coenonympha tullia* (Müller, 1764)	3,212	459	734 (92)	95 (91)	20	24	17	12	14	11	12
99.	*C. glycerion* (Borkhausen, 1788)	8,288	1,184	1,891 (95)	414 (91)	17	22	15	18	19	17	14
100.	**C. hero* (Linnaeus, 1761)	0	0	0	0	0	0	0	0	0	0	0
101.	*C. pamphilus* (Linnaeus, 1758)	6,829	976	1,384 (95)	480 (91)	33	32	24	22	22	22	19
102.	*Aphantopus hyperantus* (Linnaeus, 1758)	54,783	7,826	12,798 (95)	2,270 (91)	63	55	50	45	51	52	55
103.	*Maniola jurtina* (Linnaeus, 1758)	667	95	149 (92)	26 (97)	3	3	2	2	3	3	2
104.	**Hyponephele lycaon* (Rottemburg, 1775)	0	0	0	0	0	0	0	0	0	0	0
105.	*Erebia ligea* (Linnaeus, 1758)	34,658	4,951	12,849 (97)	808 (91)	56	32	47	25	50	32	54
106.	*E. embla* (Thunberg, 1791)	787	112	201 (94)	15 (91)	5	3	4	6	3	4	4
107.	*E. disa* (Thunberg, 1791)	413	59	162 (94)	0	0	1	< 1	2	1	2	0
108.	*E. polaris* (Staudinger, 1871)	542	77	283 (94)	0	0	0	1	1	2	0	1
109.	*E. pandrose* (Borkhausen, 1788)	966	138	538 (97)	0	0	1	2	3	2	1	2
110.	**Melanargia galathea* (Linnaeus, 1758)	0	0	0	0	0	0	0	0	0	0	0
111.	*Hipparchia semele* (Linnaeus, 1758)	1,551	222	427 (93)	121 (91)	4	5	6	4	3	4	2
112.	*Oeneis norna* (Thunberg, 1791)	133	19	47 (97)	0	0	0	1	2	1	1	< 1
113.	*O. bore* (Schneider, 1792)	64	9	28 (93)	0	0	0	1	1	1	< 1	1
114.	*O. jutta* (Hübner, [1806])	3,894	556	1,390 (94)	0	0	24	1	19	1	15	0

Discussion

The progress of NAFI mostly depends on the number of participants. During the seven-year period a total of 306 persons took part in the scheme. One fifth (188, 21%) of all members of the Lepidopterological Society (altogether about 900) have participated in NAFI for one year at least. Another 118 participants, comprising more than one third of the total (39%), have been naturalists but not members of the Society. We suggest that there are two main reasons for the positive progress. Firstly, the general interest in butterflies has grown in Finland during the 1990s, and secondly, NAFI has taken good care of the participants. They have been supplied with regular feedback of their work via the annual results published in the Society's bulletin, and most of the participants have personally received new forms with a covering letter every spring. In addition, five-year results (1991–1995) with accumulative maps of all 114 butterfly species have been published (Marttila & Saarinen, 1996b). Non-member participants have become acquainted with NAFI through reprints, the media and previous participants.

Validity of methods. The data on forms and in computer files is checked carefully as described under *Methods* above, but still the most serious question is how to ensure the reliability of the information sent in on forms. This problem is aggravated by the fact that all the participants are not registered members of the Lepidopterological Society. In order to minimize the risk of incorrect data, all questionable observations, whether provided by a member or not, have been checked by contacting the observer. There are some details which have made the authors dubious, such as the species being reported well outside of its known distribution area, or a periodical species being observed in a wrong year, or where a rare species inhabiting mires has been reported whereas no information on more common species living in similar environments has been given. If there still exists some doubt as to the authenticity of the observation after it has been followed up, it has not been computerized.

Broadly speaking, the maps based on the NAFI results are in line with earlier maps published in the handbook of Finnish butterflies (Marttila *et al.*, 1991). There is no reason to suspect that previous knowledge would not have been good enough to

show the essential distribution of any species living in Finland. Some similar species (*Plebeius argus/P. idas, Argynnis aglaja/A. adippe*), previously known to have different distributions, have provided a good control. The differences between these species have also been revealed in NAFI.

The observation network covers almost the whole country, except that a few regions in the northern part of Finland are poorly represented in comparison to the southern parts of the country. The poor network in the north causes an effect that the frequencies of 'northern' species tend to be underestimated. To avoid this possible bias the country could be divided into two subareas, a southern and a northern one, after which the frequencies of "northern" species could be assessed independently. However, even in "northern" species the distribution areas vary greatly from one species to another. That would cause a difficulty how to define the position of the line with no risk of underestimating or overestimating certain species occurring in the area concerned.

Something new already. The seven-year data applies to almost 890,000 butterfly individuals, representing all the Finnish resident species (95) and 8 of a total of 19 non-resident species. The NAFI results are largely parallel to previous knowledge of Finnish butterflies (Marttila *et al.*, 1991, Rassi *et al.*, 1992, Somerma, 1997), but the data also suggest some new trends.

The NAFI results point to the possibility of changes in the distributions of some species. When the distribution maps are compared to corresponding ones given in the handbook of Finnish butterflies (Marttila *et al.*, 1991), *Limenitis populi, Apatura iris* and *Argynnis paphia* show some expansion, while the ranges of *Lycaena helle, Glaucopsyche alexis, Issoria lathonia* and *Maniola jurtina* have decreased.

The trends in annual frequencies in nine species, almost all declining, *might* show — we say so, though the trends during the period were statistically significant — that the status of these species is undergoing a change.

The results for two species are alarming in particular. *Lycaena hippothoe* and *Glaucopsyche alexis* have had surprisingly low individual numbers, 2,697 and 308, respectively. In addition, there has been a significant fall-off in the annual frequencies of *L.*

hippothoe, while the range of *G. alexis* has strongly decreased in comparison to the distribution map given in the book of Finnish butterflies (Marttila *et al.*, 1991). The book classifies these species as fairly common and scarce, respectively, whereas the recent book on Finnish threatened Lepidoptera does not mention the species at all (Somerma, 1997).

The seven-year period of NAFI is not long enough to provide extensive conclusions about changes in the status of butterflies. Some changes observed during the period might form a part of natural long-term fluctuation, but some of them might also be cautionary, indicating an actual decline in adversely affected species. Most importantly, the scheme reveals the downward trend of these species earlier than could be detected previously. Thus, conservation projects, if needed, can also be launched earlier than before.

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HOSTS: a database of the host plants of the world's Lepidoptera

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Summary. The Natural History Museum's HOSTS database is intended to provide eventually a thorough inventory of the host plants of the world's Lepidoptera. The methods used for data capture, the editing and validation processes, the database structure and the inherent limitations of the project are described. The current status of the database, its actual and potential products, and possible directions for future development are outlined, and the problems in making it widely available while safeguarding intellectual property rights are discussed.

Zusammenfassung. Die Datenbank HOSTS am Natural History Museum, London, hat eine umfassende Zusammenstellung der Wirtspflanzennachweise für alle Lepidopterenarten der Erde zum Ziel. Methoden der Datenerfassung, der Herausgabe- und Validierungsprozess, die Struktur der Datenbank und die systembedingten Grenzen des Projektes werden beschrieben. Ferner werden der gegenwärtige Stand der Datenbank, ihre aktuellen und potentiellen Nutzanwendungen sowie mögliche Richtungen für die künftige Weiterentwicklung vorgestellt. Ein wichtiges Problem besteht darin, Urheberrechte an geistigem Eigentum mit den Anforderungen an eine weite Verbreitung der gespeicherten Information in Einklang zu bringen.

Résumé. La banque de données HOSTS du 'Natural History Museum' à Londres a comme objectif de fournir un inventaire exhaustif des plantes-hôtes des Lépidoptères du monde. Les méthodes employées pour la collecte des données, pour l'édition et les procédés de validation, pour la structure de la banque de données et les limitations inhérentes du projet sont décrits. L'état actuel de la banque de données, les produits actuels et potentiels qu'elle livre et les directions pour un développement futur sont également décrits, ainsi que les problèmes posés par sa mise à la disposition générale en ce qui concerne la protection des droits de propriété intellectuelle.

Key words: Lepidoptera, host plants, world resources, inventory database, data processing, intellectual property rights.

Introduction

Information on what eats what and where in the complex web of relationships between caterpillars and plants is of use to a very wide range of users. The demand for such information is

increasing as a corollary of the increase in demand for information (and rapid access to it) by, notably, environmental and agricultural interests. The provision of such information requires access to data that has both geographical and taxonomic breadth. With some 135,000 recognised Lepidoptera species feeding potentially on more than a quarter-million species of plants, the eventual size of an even remotely credible databank is considerable.

A great deal of information on Lepidoptera host plants is already available for, notably, Europe and North America. But most is in either printed (i.e., published) or manuscript form, the latter often as card indexes, the former scattered in an enormous literature that covers three centuries. Attempts have been made to compile regional compendiums of host plant data. These include, for example, that by Tietz (1972) for the Macrolepidoptera of North America, and by Emmet (1992) for Great Britain and Ireland. The only attempt at a global compendium is that by Zhang (1994) for Lepidoptera of economic importance.

The integration of Lepidoptera host plant data and the efficient sorting, indexing and interrogation of that data to answer a wide range of questions for a wide range of users necessitates its being in the form of an electronic database. In the late 1980's staff of the NHM Lepidoptera Section began collecting data in electronic form as a series of pilot projects. In 1993 we developed the concept of a large database that would provide eventually world-wide coverage and be flexible enough to deliver both printed and electronic products to a user base that included amateur entomologists and professional biologists involved in systematics, conservation, agriculture, forestry, biocontrol and quarantine regulation. This concept has evolved into the HOSTS database.

Comparatively small and specialised data sets are used routinely by systematists to enrich the data content of taxonomic treatments by providing an ecological context. The observed host plant ranges of small groups of Lepidoptera may well, by their uniformity, reinforce hypotheses of relationship: larvae of *Utetheisa* (Arctiidae), for example, feed on Leguminosae and Boraginaceae, and morphologically distinct species-groups are restricted in their feeding to one or other host family.

Easily accessible data on Lepidoptera host plants allows the conservationist to at least predict the presence of particular insects

in a habitat given the requisite botanical information. It also permits the setting of clear diversity objectives in habitat enrichment and restoration — a "wish-list" of Lepidoptera species can be matched against a list of the host plants necessary for the species to establish themselves.

Rapid access to data on the insects attacking particular plant species (rather then vice versa) is vital to applied entomologists. The recent discovery of novel damage to cypress foliage in nurseries in East Anglia required a rapid response and using the HOSTS database we were able to narrow the possibilities to two probable and two possible North American Argyresthiidae species in less than five minutes. Eliminating three of the four (leaving one of the two "probables") by checking voucher specimens against a near-comprehensive reference collection took another ten minutes. This identification would have taken considerably longer using conventional means.

Access to comprehensive or near-comprehensive host plant data is also invaluable in biocontrol studies, helping to suggest appropriate groups and regions for further investigation, to narrow searches and to warn of potential problems in species that are not host-specific.

HOSTS, while at present by no means giving universal coverage, provides us with the wherewithal to interrogate a large databank to find the host plants or host plant ranges of a species, or group of species, and to do the opposite and search for the larvae that feed on a plant or group of plants. We can perform these searches at all taxonomic levels and limit searches by country or zoogeographic region. We can examine the numerical structure and frequency distribution of host plant utilization (Robinson, 1998), examine correlations, and provide printed compendiums and indexes listing either plants and the larvae that eat them, or larvae and their host plants at geographical scales from country to global.

In this paper the methods used for data capture, database structure, editing and validation processes and the inherent limitations of the project are described. The current status of the HOSTS database, its actual and potential products, and possible directions for future development are outlined, and the problems inherent in making it widely available while safeguarding intellectual property rights to the entire compilation are discussed.

Data acquisition and data sources

Our early priorities were to abstract major printed compendiums of host plant information together with major manuscript resources to provide a large and credible base of information that could then be further developed by the addition of sources that contained fewer records but were complementary to the major sources. Examples of major printed sources that were abstracted include McGugan *et al.* (1958–1965), Tietz (1972) and Scott (1986) — North America, Silva *et al.* (1968) — Brazil, Yunus & Ho (1980) — Malaysia, Emmet (1992) — Great Britain and Ireland.

Major manuscript resources included: Edward Meyrick's ledger of the host plants of the world's Microlepidoptera, culled from correspondence, literature and the many thousands of specimens that passed through his hands in the space of some sixty years from about 1876 to 1936; the card index compiled by Comstock and Henne for North American Microlepidoptera that complements Tietz (1972) and which is housed in the Los Angeles County Museum of Natural History, and the comprehensive card catalogue of Nymphalidae host plants developed by Phillip Ackery (The Natural History Museum (NHM), London).

Progressively smaller sources were included as the project progressed; literature searches and the polling of fellow-specialists for suggestions of key works for inclusion resulted in a steady accumulation of data. In 1995 it was decided that North America would be the first geographical priority for full development of the database, followed by the Oriental region.

Electronic and manuscript lists of host plants were solicited from colleagues both in the NHM and elsewhere. A demonstration database was established on the World Wide Web and information solicited either as e-mail, word-processor files, databases or directly via a WWW input form (see below). The response to this "public appeal" was surprisingly generous; large data sets donated include Japanese Lepidoptera on Fagaceae (Dr. N. Teramoto), world Lycaenidae (Dr. Konrad Fiedler) and California butterflies (Ms. Marian Fricano). We would be delighted to receive additional contributions!

Abstracting was carried out, for the most part, by volunteers (work experience students) and by students undertaking vacation

work. The minimum usable information — names of Lepidoptera and host plants — was typed into a temporary Paradox database together with any additional relevant information such as abbreviated details of damage, locality and cited (secondary) sources. The field structure of the temporary database was restricted to the bare minimum required and expanded only later to the complete format (see below). Repeated information, such as author and date of the source, was added subsequently as a global change. The accuracy of transfer was, overall, surprisingly good and the tenacity and responsibility of our work-experience students, some as young as fourteen and dealing with a subject entirely novel to them, was laudable.

Despite initial optimism, comparatively few sources proved suitable for data acquisition by optical character recognition — the narrative rather than tabular form of most sources precluded efficient conversion and even where the format was suitable, poor print quality often resulted in an unacceptably high level of error in conversion. But OCR has proved useful in some cases and we consider it a valuable adjunct to abstracting by manual methods. In these cases the source is scanned using a Hewlett-Packard Scanjet 6100C and OCR performed to deliver ASCII text using Omni-Page (Caere). From this, column-tabulated files are generated (for checking) then converted into delimited ASCII text using WordPerfect 6.1 and imported into Paradox.

Database structure

HOSTS is a "flat" database comprising 23 alphanumeric fields totalling 313 characters. Abstractors fill a maximum of 15 of these fields (* — asterisked), but the abstracting of a single source typically involves only seven or eight fields. Unfilled fields are either left blank, filled globally, filled from other relational databases, or involve check "signatures" as part of subsequent editing and validation. The fields are as follows (field length is in brackets):

Family (5): Abbreviation of family-group name, e.g. NOCTU(idae), derived from first five letters; ambiguities such as HELIOdinidae and HELIOzelidae are resolved by adaptation, e.g., HELID and HELIZ. This field and the next are entered automatically by relational linking to a database of the generic names of the Lepidoptera (derived from Nye (1975–91) and developed by B. R. Pitkin) and act as a check on spelling of the generic name.

Subgp (5): Abbreviation of (usually) subfamily derived as above.

NCA (3): Name Check Authority — an entry indicates verification that the insect name is currently valid and comprises initials of checker or source used (e.g., CLE indicates that the name used is compatible with *Checklist of the Lepidoptera of Europe* by Karsholt & Razowski (1996)).

Genus (20)*: Insect generic name.

Species (20)*: Insect species name.

Subspecies (20)*: Insect subspecies name.

Author (16)*: Insect author(s) — in full unless exceeding field length; names are abbreviated according to a table of standards (e.g., Hübner, Denis & Schiff.).

Damage (20)*: Succinct damage descriptor which may be abbreviated (e.g., in leaves, on fls/fruits/leaves); "in" is used specifically to denote internal feeding or specified concealed feeding ("in rolled leaves"); the use of "on" tends to be somewhat generalised in the literature but we have tried to restrict its use to external or unspecified concealed (but not internal) feeding. This field may also include indications of, for example, ant associations ("on flowers + ants").

Plantgenus (17)*: Genus of host plant or, in the occasional case of a carnivorous larva, the insect prey. Very rarely plant and insect genera have identical names and ambiguity is avoided by suffixing an insect generic name with a "Z".

Plantspecies (20)*: Species of host plant or prey insect.

Plantsubspecies/var (20)*: Subspecies or varietal name of host plant.

Plantfamily (17)*: Family of host plant. This field is entered automatically by relational linking to a database of the generic names of plants (derived from Brummitt (1992)) which acts as a check on spelling and current validity of the generic name. The terms *polyphagous* and *detritophagous* may be used in this field with appropriate modifiers in the *Damage* field. Other non-standard terms used are: *Algae; Filicopsida* (i.e., unidentified fern(s)); *Fungi; Insecta* (i.e. predaceous — with generic name of host in the *Plantgenus* field (see above); *Lichenes; Musci.*

PCA (3): Plant check authority. As NCA above. "JTK", for example, indicates the name is valid in Kartesz's (1994) checklist of the vascular flora of North America.

Locality (20)*: Country from which the host record originates. Large countries (e.g., Brazil, USA) are subdivided into states and the state entered from a table of standard abbreviations (e.g., USA: TX). Occasional captive rearing records (see below) refer to rearing of stock originating from one country on a "substitute" food plant in another. Provenance data for species involved in such "hobby rearings" is recorded as, for example, "Ecuador (prov.)". A relational database can be used to provide a link from this field to the major zoogeographic region from which the record originates.

Source (16)*: The source from which the record was abstracted or received (i.e., the primary source). This may be an author's name (e.g., "Fletcher", "Brown *et al.*"),

indicate a manuscript or database source, ("Meyrick MS"; "Intachat db") or an unpublished source that cannot be consulted ("Jones pers. comm."; "WWW input"). Source details are held in a bibliography maintained as a word-processor file; this will be converted eventually into a database.

Date (6)*: Date of the source; field size permits use of square brackets where source date is determined by external evidence.

Secondary source (16)*: If the source cites an earlier publication as the original source of the record this is entered here; a blank field may not guarantee that the source is the original. Abstractors have often had difficulty in identifying secondary source citations; in the abstracting of some sources, secondary citations were ignored.

Sec-date (6)*: Date of secondary source.

Original name (30): Entered globally as a concatenation of *Genus* + *Species* + *Subspecies* fields (above) immediately after abstracting; permits back-tracking of the name in the original reference. This was not recorded in the early stages of database development and an entry followed by "[R]" indicates retrospective entry. Retrospective entries may not match the version of the name used in the source.

Original host name (30): Entered for the host plant as the preceding field, and with the same limitations.

CR (1)*: Captive record: the plant is not known to be a host in the field but is accepted by larvae in captivity. The entire record is only included if development was completed successfully. Entries are "Y" (yes), "N" or blank (no), or "?" (maybe).

Reliab (1)*: Reliability. Possible entries are "?" (record dubious), "N" (record is an error), or "O" (oviposition — only — observed). Doubtful identifications of insect or plant are indicated by suffix queries in the name fields (e.g., "*Solanum tuberosum* (?)" [*Solanum*, but only maybe *tuberosum*]; "*Solanum* (?)" [maybe a *Solanum*]; the latter is vague enough to earn also a "?" in the *Reliability* field.

Nathost (1): Possible entry is "N" when the host plant is definitely not native to the country or area where the record originates. Many crop plants and ornamentals, for example, are not native to the countries in which they are grown. This field is not used in this phase of database development.

Editing and validation of nomenclature

Once abstracting is complete, new records are reformatted with the full field structure of the HOSTS database and any global fills (such as source and date) are performed. The *Original name* and *Original host name* fields are filled as described above. Subsequent phases of editing and validation involve cycles of progressive refinement, to correct mis-spellings and to modernise and standardise insect and plant nomenclature. Problem entries

are carried over into another cycle. Once a substantial number of records have been prepared for editing, the automatic checking of the insect and plant generic names described above provides an opportunity to correct spellings and plant generic synonymy. Author names are standardised and plant and insect names are then checked electronically against two databases of previously-validated names. These databases allow us also to correct automatically many frequently-encountered plant and insect synonymies and to convert many common vernacular names of plants. Names that still fail to achieve a validation check are then processed against the other nomenclatural databases available to us (such as Missouri Botanical Gardens' database of Peruvian plants and Scoble's (NHM) catalogue of Geometridae) and recombined or synonymized as necessary to achieve a contemporary and consistent nomenclature.

Remnant non-validated names are then checked manually against recent authoritative sources (checklists and monographs, the Missouri Botanical Gardens VAST database on the WWW) and, as a final resort the NHM Lepidoptera systematic card catalogues (most families updated only to 1982) and *Index Kewensis* on CD-ROM (which only records the existence of a plant name but does not give its current status).

Editing and rendering current and consistent the insect and plant nomenclature and other elements in the HOSTS database is the most time-consuming part of the operation. It inevitably throws up inconsistencies between regional taxonomies for plants and Lepidoptera and requires compromise.

Limitations, accuracy and problems

No global catalogue of Lepidoptera host plants can ever be comprehensive. Neither can its content ever be entirely accurate. While it would in theory be possible to search and abstract the entire world's entomological literature, the resource implications of such a task are monumental. So in practice a strategy of prioritisation is needed to achieve a credible compilation using finite resources. The strategy adopted here is that of abstracting the largest sources first then adding complementary key works, as described above. In a few instances, complementary key works may include the entire oeuvre of a particular author who has

specialised in the monographing of reared material (e.g., Kumata on Gracillariidae).

While it would be admirable to trace all host plant records to their original source, this is not considered practical for the entire Lepidoptera. However, in developing adjunct databases to HOSTS for the world's bombycoid moths and the Neotropical Rhopalocera respectively, Kitching & Beccaloni (in prep.) are attempting just this. Several authors (e.g., Sattler, 1967 for Palaearctic Ethmiidae) have published catalogues of host plants for smaller groups in which all records have been back-tracked to their original source.

The potential sources of error in any compilation of host plant records are manifold. At the root lies misidentification of either plant or insect by the original observer or recorder. Further errors may occur in the transcription of records, a classic case being the confusion of *E.*[*ugenia*] *malaccensis* with *E.*[*ndospermum*] *malaccense*, which resulted in persistent citation of Myrtaceae as a host family for Uraniidae rather than Euphorbiaceae (Lees, pers. comm.). Confusion may occur between similar or identical plant and insect names (e.g., *Aristotelia* — Gelechiidae or Elaeocarpaceae) or a transcriber may confuse similar generic names such as *Asperugo* (Boraginaceae) and *Asperula* (Rubiaceae). Confusion may occur when the context is in a language with which the abstractor or transcriber is unfamiliar. A history involving synonymy that is later reversed may result in a perfectly valid host record being switched from one species to another.

Rearing caterpillars obtained from eggs from a captured female on a host plant found acceptable by trial and error may result in the publication of a host record that is erroneous in that the relationship is entirely artificial. Such laboratory rearings are not always clearly cited as such.

Erroneous host plant records are cumulative — repeated citation gives them a spurious authority and they are extremely difficult to detect and delete. As errors accumulate, there is a danger that the "noise" of different erroneous records may obliterate a correct insect-plant relationship especially if this is a single observation on a unusual host plant.

Much of the original abstracting for this work was carried out by volunteers unfamiliar with plant and insect nomenclature

and unsure of the meaning of some contexts. Manuscript sources were not always perfectly legible. So there is potential for further errors being added in the abstracting process. Resources did not permit us to trace all records to origin nor to check all abstracting work.

HOSTS: current status

At the time of preparation of this paper (June 1998) the HOSTS database contained 102,981 records covering:

	Lepidoptera	Plants
Families	99	299
Genera	5315	3103
Species	20,457	10,216

Geographical coverage of the database shows some regional bias, reflecting geographical priorities for abstracting. Numbers of records for each major zoogeographic region are:

Regions	Records
Palaearctic	20,088
Nearctic	38,793
Neotropical	8295
Afrotropical	6774
Oriental	20,623
Australasia	4384

There are additionally some 251 records from Hawaii, 164 from New Zealand and 3609 records that are attributed either to the Holarctic region or have no location attributed. "Pantropical" and "cosmopolitan" species are counted here as if they were from the Oriental region.

HOSTS: the products

It is intended that a series of major products from HOSTS should include printed compendiums of data for at least some of the major zoogeographic regions covering all Lepidoptera and plant groups. Such a compilation has just been completed for North America (Robinson *et al.*, in prep.) and one is in preparation for the Oriental region. Poorly served by existing published sources, a host plant catalogue for the Afrotropical

region is also badly needed but development of the database to the point where this can be produced will necessitate additional funding.

Other medium-term products envisaged include catalogues of the Lepidoptera that feed on particular plant families. The current level of interest in legume biology, for example, suggests that this would be an appropriate group for a global catalogue.

The HOSTS database can also be used to generate data for question-driven research and collaboration in this area is currently being solicited, and an extension of preliminary work on frequency distribution of host plant specificity is envisaged.

HOSTS on the WWW and the future

The current demonstration database on the Web
http://www.nhm.ac.uk/entomology/hostplants
contains some 3000 records and is intended to publicise the HOSTS project as well as provide useful public-domain information. The database search program permits the user to search by genus or species name of plant or insect and then to perform cross-referencing searches. The site also includes an input form that allows the user to contribute individual records to the database and includes a request for additional information in a variety of electronic formats (see above).

The value of HOSTS as a look-up tool for specific Lepidoptera-plant associations is inestimable, and it is inevitable that, in response to demand, the entire database will be made available for search on the Internet in the near future. However, the resources that have been devoted to the development of HOSTS are such that Internet availability cannot jeopardise the published products and other possible commercial or academic applications of the database.

The search structure of the present WWW database would result in an unmanageably large number of records being returned to the enquirer if the database were to be enlarged and would permit downloading of unacceptably large slices of the dataset if it were applied to HOSTS. We envisage that HOSTS will be mounted on the Web with a search routine that requires the user to narrow his search by taxonomic (plant and insect) and geographic criteria, and possibly omit fields until the number of

records retrieved falls below a specified limit. Only then will data be transmitted to the enquirer.

Further into the future, we envisage rapid growth of metadata handling capabilities in which cross-linking to other databases will be possible. This will allow the almost instantaneous retrieval of supplementary taxonomic data on the plants and the insects, geographic information, illustrations and, indeed, all that we can presently retrieve by pulling the drawers of reference collections and combing the shelves of libraries together with much, much more.

Pooling resources of host plant information is just one way in which we can propel data into the public domain. We would be delighted to hear from anyone wishing to share their data with us with this aim in view.

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A commercial interest in systematics, or a systematic interest in commerce? The Moroccan butterfly names of M. R. Tarrier

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Summary. Moroccan butterfly names recently raised by M. R. Tarrier (1996, 1998c) are critically appraised. Rarity status allocated to Moroccan butterflies (Tarrier, 1998a) is shown to be highly subjective and closely correlated to prices in a commercial butterfly price list (Tarrier, [1997b]). It is suggested that the basis on which names have been raised and on which calls for the protection of butterfly habitats have been made, represent a cynical attempt to promote commercial butterfly sales. It is further suggested that journal editors must bear responsibility for facilitating publication of such material. The names *amelnorum, antiatlasicus, arahoui, edithae, fairuzae* and *megalatlasica* are synonymised with existing names.

Zusammenfassung. Die von M. R. Tarrier (1996, 1998c) kürzlich aufgestellten Namen für marokkanische Tagfalter werden kritisch revidiert. Der vermeintliche "Seltenheitsstatus" marokkanischer Tagfalter im Sinne Tarriers (1998a) ist hochgradig subjektiv und korreliert eng mit den Preisen in einer kommerziellen Tagfalterliste desselben Autors (Tarrier, [1997b]). Obwohl die Benennungen auch als Argument zum Schutz der Tagfalterhabitate ins Feld geführt wurden, scheint die Grundlage für die vorgenommenen taxonomischen Änderungen ein zynischer Versuch zu sein, den kommerziellen Schmetterlingshandel mit "seltenen" oder "endemischen" Taxa zu steigern. Herausgeber wissenschaftlicher Zeitschriften müssen sich bewußt sein, daß sie mitverantwortlich sind für die Veröffentlichung derartig fragwürdiger Arbeiten. Die Namen *amelnorum, antiatlasicus, arahoui, edithae, fairuzae* und *megalatlasica* werden formell mit bereits existierenden Taxa synonymisiert.

Résumé. Des noms de papillons marocains récemment érigés par M. R. Tarrier (1996, 1998c) sont évalués de façon critique. Il est démontré que le statut de rareté attribué aux papillons marocains (Tarrier, 1998a) est hautement subjectif et en étroite corrélation avec les prix dans une liste de vente commerciale de papillons (Tarrier, [1997b]). Il est suggéré que la base sur laquelle des noms ont été érigés et des appels pour la protection d'habitats lépidoptériques ont été adressés, représente une entreprise cynique ayant pour but la vente commerciale de papillons. Il est également préconisé que les éditeurs de revues ont une large part de responsabilité en facilitant la publication d'un tel matériel. Les noms *amelnorum, antiatlasicus, arahoui, edithae, fairuzae* et *megalatlasica* sont établis comme synonymes de noms existants.

Key words: Lepidoptera, Rhopalocera, nomenclature, rarity status, commercial price, Morocco.

Introduction

In preparing a book on Maghreb butterflies (Tennent, 1996), the author became aware of several unfamiliar Moroccan butterfly names: *Euchloe falloui fairuzae, Plebejus allardi antiatlasicus, Melanargia occitanica megalatlasica, Melanargia ines arahoui* and *Neohipparchia hansii edithae*, and learned from a colleague that they had first appeared in a commercial butterfly catalogue produced by Michel Tarrier, Malaga, Spain. Although the names were not then published in the International Code of Zoological Nomenclature sense, the sales list was widely distributed. When Tennent (1996) went to press, the names were believed to also be in press.

Since then a series of papers on Moroccan butterflies by Tarrier have been published, including formal descriptions of the above names (Tarrier, 1996). More recently, a plea for the conservation of butterfly habitats in Morocco, said to be based on species rarity status was presented (Tarrier, 1998a) and a further new taxon, *Tomares mauretanicus amelnorum*, described (Tarrier, 1998c). In the opinion of the present author, these publications combine to add significantly to confusion surrounding Palaearctic butterfly systematics and equate, collectively, to a cynical attempt to promote commercial interest at the expense of nomenclatural stability. They also raise the serious question of how such papers find their way into print.

This paper synonymises 'new' names with previously named taxa and presents hitherto unpublished data concerning type material. It also comments on the perceived status of some Moroccan butterflies, making a comparison with prices in the latest butterfly price list available to the author (Tarrier, 1997b) and suggests a close connection between the two.

The author's acknowledgement for having rendered material assistance in research leading to these publications (Tarrier, 1996: 211; 1998a: 213) is misleading, conferring as it does an assumption of accordance with the content. Some background is appropriate and this is adequately illustrated by examining the circumstances leading to publication of the name *antiatlasicus* Tarrier, 1996. In 1993, the author provided M. Tarrier with copies of various early entomological papers on request, including Oberthür (1874), without knowledge of the line of research being pursued, or

indeed whether any line of research was being followed. Early in 1994 a colleague telephoned to enquire what the author knew of a number of unfamiliar butterfly names, including *antiatlasicus*, seen in a recent sales list (Tarrier, [1994]) and the author subsequently obtained from Tarrier a copy of the draft of a manuscript, a substantially revised version of which was later published in the journal *Alexanor* (Tarrier, 1996). This draft introduced the name *antiatlasicus* but did not, for example, include in the references a paper by De Prins *et al.* (1992), which provides critical information for anyone carrying out research into North African *Plebejus*.

The author learned that justification for raising the name *antiatlasicus* was based on perceived phenotypic differences between the *allardi* population reported from the Anti-Atlas mountains of Morocco by Bozano & Giacomazo (1988), and the original brief description of *allardi* provided by Oberthür (1874). M. Tarrier was unaware of the paper by De Prins *et al.* (1992) or that *allardi* was locally common in Tunisia and had not seen any material from those countries.

It was also learned that the manuscript had apparently, in 1993 or early in 1994, been rejected by the editor of a European journal. It is probable that by this time, advertisement and subsequent sale of specimens of 'new' races of butterflies made retraction of names virtually impossible. A revised version of the manuscript, which did refer to De Prins *et al.* (1992) and to other publications overlooked in the original draft, was published in *Alexanor* several years later (Tarrier, 1996).

Prior knowledge of the intended publication of five of the six new names synonymised in this paper, provided the opportunity of examining type material which the early draft indicated had been deposited in the collections of the Muséum National d'Histoire Naturelle, Paris, and the Departement de Zoologie et d'Ecologie Animale, Institut Scientifique, Université Mohammed V, Rabat, Morocco. Relevant details appear below. Published data relating to type material included a specific date of capture, although it will be seen that the actual dates which accompany type specimens are general and cover a two week period. The whereabouts of paratypes said to be deposited in 'coll. Tarrier' is not known and they are considered likely to have been sold.

New synonymy
Euchloe falloui Allard, 1867

Euchloe falloui fairuzae Tarrier, 1996, **syn. n.** — *Alexanor* 19(4): 195.

Type data published. Holotype ♂, Tizi-n-Tinififft, Maroc, djebel Sarrho, Anti-Atlas oriental, 1600 m, 5.iv.1993, M. Tarrier leg. (Rabat); 'numerous' male and female paratypes, same locality, 1500–1800 m, 5 and 6.iv.1993 (Paris, Rabat, Tarrier).

Type material examined (8 ♂, 2 ♀). Holotype ♂, Tizi-n-Tinififft, 1–15.iv.1993; M. Tarrier leg.; 3 ♂, ♀ paratypes, same data (Rabat); 4 ♂, ♀ paratypes, same data (Paris).

Comment. Said to be smaller than typical *falloui* and with a more pointed forewing apex. Like *Melanargia ines* Hoffmansegg, 1804 (see below), it is not unusual to find individuals or populations of butterflies in arid regions that are generally smaller than the same species in cooler or in more northern habitats (cf. figs. 21, 22, 28 on pl. 5 of Tennent, [1996]. The name *fairuzae* is a junior subjective synonym of *falloui*.

Tomares mauretanicus Lucas, 1849

Tomares mauretanicus amelni Tarrier, [1997b] — Lepidopterum [sic, recte Lepidopterorum] Catalogus, butterflies of Morocco, general pricelist 1997: 3 (unpublished manuscript name).

Tomares mauretanicus amelnorum Tarrier, 1998, **syn. n.** — *Alexanor* 20(2): 120.

Type material not examined. *Tomares mauretanicus* is an immensely variable species, with some characters subject to considerable local and individual variation and others clinal (Tennent, 1996: 28). The name *amelnorum* is a junior subjective synonym of *mauretanicus*.

Plebejus allardi Oberthür, 1874

Plebejus allardii antiatlasicus Tarrier, 1996, **syn. n.** — *Alexanor* 19(4): 198.

Type data published (21 ♂, 7 ♀). Holotype ♂, Tizi-n-Tarakatine, Maroc, Anti-Atlas sud-occidental, 1600 m, 10.iv.1993, M. Tarrier leg. (Rabat); 18 ♂, 4 ♀ paratypes with same data, but 8 and

10.iv.1993; 2 ♂, 3 ♀, Aït Abdallah, Maroc, Anti-Atlas occidental, 1500 m, 9.iv.1993, M. Tarrier leg. (Paris, Rabat, Tarrier).

Type material examined (8 ♂, 5 ♀). Holotype ♂, Tizi-n-Tarakatine, 1–15.iv.1993, M. Tarrier leg.; 3 ♂, 4 ♀ paratypes, same data (Rabat); 4 ♂, ♀ paratypes, same data (Paris).

Comment. Upperside blue suffusion of female '*antiatlasicus*' was said to be very extensive, especially on the hindwings ('weak' blue suffusion in nominotypical *allardi*). Orange submarginal lunules were said to be usually present on the upperside forewing of the female, whilst those on the hindwing were said to be large or very large (in nominotypical *allardi* absent on forewings, large on hindwings). Comparison with the four female uppersides of *allardi* illustrated by Tennent (1996: pl. 12, figs. 33–36) shows that this is not so. All diagnostic features provided for *antiatlasicus* fall within the range of typical *allardi* which is a variable butterfly, particularly in the female sex. The name *antiatlasicus* is a junior subjective synonym of *allardi*.

Melanargia ines ines Hoffmansegg, 1804

Melanargia ines arahoui Tarrier, 1996, **syn. n.** — *Alexanor* 19(4): 206.

Type data published. Holotype ♂, Tizi-n-Taghatine, Maroc, djebel Siroua, Anti-Atlas oriental, 1800 m, 7.vi.1993, M. Tarrier leg. (Rabat); 'numerous' males and females, same data (Paris, Rabat, Tarrier).

Type material examined (10 ♂, 4 ♀). Holotype ♂, Tizi-n-Taghatine, 1–15.iv.1993, M. Tarrier leg.; 6 ♂, 2 ♀ paratypes, same data (Rabat); 3 ♂, 2 ♀ paratypes, same data (Paris).

Comment. Said to be small and dark with extensive dark markings. Individuals with extensive black markings are not uncommon (f. *jahandiezi* Oberthür, 1922). In arid places, including the Moroccan Anti-Atlas and southern regions of Algeria and Tunisia, small specimens are not unusual (Tennent, 1996: 72). The name *arahoui* is a junior subjective synonym of *ines*.

Melanargia occitanica pelagia Oberthür, 1911

Melanargia occitanica megalatlasica Tarrier, 1996, **syn. n.** — *Alexanor* 19(4): 204.

Type data published. Holotype ♂, Tizi-n-Talhremt, Maroc, Haut Atlas septentrional, 1900 m, 28.v.1993, M. Tarrier leg. (Rabat); 'numerous' males and females, same locality, v.–vi.1992 and 1993 (Paris, Rabat, Tarrier).

Type material examined (10 ♂, 4 ♀). Holotype male, Tizi-n-Talhremt, 1–15.vi.1993; M. Tarrier leg.; 5 ♂, 4 ♀ paratypes, same data; ♂, same locality, 16–31.v.1993 (Rabat); 3 ♂ paratypes, same data (Paris).

Comment. Features said to separate *megalatlasica* (black markings 'thinner' on both surfaces, ocelli smaller) from Moroccan populations of *occitanica* fall within the range of *occitanica pelagia* Oberthür, 1911 and the name *megalatlasica* is a junior subjective synonym of *pelagia*. A female specimen illustrated by Tennent (1996: pl. 20, fig. 17) is wrongly identified (Tennent, 1996: 160) as *M. ines ines*; this should read *M. occitanica pelagia*.

Neohipparchia hansii Austaut, 1879

Hipparchia hansii tansleyi Tarrier, 1995 — *Linn.belg.* 15(1): 42, 40 (figs. 7 [9, 10], 8 [7, 8], 9 [8]).

Hipparchia hansii edithae Tarrier, 1995 — *Linn.belg.* 15(1): 40 (figs. 7 [7], 8 [5], 9 [6]) nom. nud.

Hipparchia hansii edithae Tarrier, 1996, **syn. n.** — *Alexanor* 19(4): 208.

Type data published. Holotype ♂, Tizi-n-Talhremt, Maroc, Haut Atlas septentrional, 1900–2200 m, 28.viii.1993, M. Tarrier leg. (Rabat); 'numerous' male and female paratypes, same locality, 10 and 12.ix.1992; 17, 19, 21, 22 and 28.viii.1993 (Paris, Rabat, Tarrier).

Type material examined (15 ♂, 1 ♀). Holotype ♂, Tizi-n-Talhremt, 16–31.viii.1993, M. Tarrier leg.; 11 ♂, no ♀ paratypes, same data (Rabat); 4 ♂, ♀ paratypes, same data (Paris).

Comment. Individual variation in *Neohipparchia hansii* is great and it is difficult to find two specimens alike. A seasoned 'splitter' would no doubt be able to support separation of almost every *hansii* population into subspecies, and variation is probably best viewed as being ecologically based (Tennent, 1996: 75). The name *edithae* is synonymous with *hansii*. It is noted that in the catalogues examined, female butterflies command double the price of males and that although the type series was said (Tarrier, 1996) to include 'numerous' specimens of both sexes, type material

available for examination consisted of 15 males and only one female.

The author did not know of the existence of the name *tansleyi* until publication and type material has not been examined. The name *tansleyi* is a junior subjective synonym of *hansii* (Tennent, 1996: 75).

Habitat protection

There is no doubt that natural habitats throughout the world require protection, nor is it in doubt that butterflies are useful indicators of biodiversity, since they are generally well known, moderately easy to identify and are sensitive to environmental pressures and conditions. Assessing the status of key species and offering advice on long-term habitat protection is a sensitive issue and one that carries with it a high degree of responsibility if advice is ever to be taken seriously. The list of butterfly habitats prepared by Tarrier (1998a), and accompanying allocation of I.U.C.N. status indicators, bears a positive correlation to prices in Tarrier's latest butterfly sales list (Tarrier, [1997b]) and is subjective to the point of irresponsibility.

Status allocated to Moroccan butterflies (Tarrier, 1998a) falls into four categories, from 'Critically Endangered' (CR) through 'Endangered' (EN) and 'Vulnerable' (VN) to 'Lower Risk' (LR). Almost all the taxa so categorised are also offered for sale (Tarrier, [1997b]). It is apparent that there is confusion between 'Critically Endangered' and 'Locally Common' as well as strong positive correlation between 'Critically Endangered' and 'expensive' (table 1).

Table 1. Moroccan butterflies: comparison of rarity status with average price

Declared status (Tarrier, 1998a)	Price per pair, DM (Tarrier, [1997b])
CR (Critically Endangered)	192.00
EN (Endangered)	93.00
VU (Vulnerable)	52.50
LR (Lower Risk)	17.00

It is not intended to enter into detailed reasons as to why much, if not most of the data in Tarrier (1998a) is inaccurate,

although it would certainly be possible to do so. Some specific examples will serve to illustrate the point.

In Morocco, five taxa of the genus *Pieris* Schrank, 1801 occur. Of these, *P. rapae mauretanica* Verity, 1908 is a crop pest, described as LR (Tarrier, 1998a: 200) and offered for sale (Tarrier, [1997b]: 2) at DM 6.00 per pair. *P. brassicae* Linnaeus, 1758, also LR, is offered for sale at DM 12.00 per pair and *P. napi segonzaci* Le Cerf, 1923, described as VU, is for sale at DM 30.00 per pair. This last butterfly was considered for many years to be confined to Djebel Toubkal in the Moroccan High Atlas and is common in the Toubkal National Park (Tennent, 1997). In recent years it has been found to be much more widespread than previously realised and probably flies throughout the High Atlas mountains (Tennent, 1996: 10). Although moderately local in distribution, it cannot by any presently acceptable criterion be considered Vulnerable.

The remaining two *Pieris* taxa, *P. napi atlantis* Oberthür, 1925 and *P. mannii haroldi* Wyatt, 1952 are two of the most local and scarce butterflies in Morocco. On the very edge of their species range, they may even warrant 'CR' listing but it is surely hypocritical in the extreme to claim that they are in critical danger of extinction (Tarrier, 1998a: 200) whilst also offering wild caught specimens for sale at DM 300.00 per pair (Tarrier, [1997b]: 2).

Likewise, *Maurus vogelii vogelii* Oberthür, 1920 and *M. vogelii insperatus* Tennent, 1996 are allocated CR status and offered for sale at DM 120.00 and DM 150.00 per pair respectively, despite the fact that, although *vogelii* was only known from one locality in the Moroccan Middle Atlas mountains for 74 years after its discovery (Tennent, 1996: 39), it is now known from a number of localities in the Middle and High Atlas mountains. Ironically, recent knowledge on the distribution of *vogelii vogelii* in the Middle Atlas is due largely to the efforts of Tarrier (1998b). The very local distribution of both races barely merits Vulnerable status and neither can be said to be Critically Endangered.

The nomenclature of western Palaearctic butterflies is in a sorry state and that used by Tarrier (1998a etc.) adds significantly to the confusion. For example, in the opinion of the author, the Satyrine butterflies *Melanargia ines, Neohipparchia hansii, Pseudotergumia fidia* Linnaeus, 1767 and *Pseudochazara atlantis*

Austaut, 1905 each fly in Morocco in a single race (Tennent, 1996), whereas Tarrier ([1997b], 1998a) listed 13 names for these four species. The very nature of systematics provides scope for a disparity of views and, whilst it would be naive to hope that the nomenclature of Tennent (1996) was universally acceptable, it did represent an attempt to bring some stability to North African butterfly nomenclature. It is difficult to avoid the suspicion that, for a commercial butterfly dealer, a profusion of names, regardless of their validity, roughly equals a profusion of Deutsche Marks.

The activities of amateur workers, of which the author is one, and professional alike, are constantly under scrutiny by misguided and ill-informed individuals who seek to stop collection of insects and other animals for any purpose. Manipulation of systematics for commercial gain by an irresponsible minority does considerable harm to those carrying out responsible field work and is to be deplored.

Häuser & Nekrutenko (1998) strongly urged journal editors to use restraint in accepting papers for publication and it is clear that journal editors must accept a major part of the responsibility for aiding and abetting publication of irresponsible material.

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Flower visitation patterns of butterflies and burnet moths in the Aggtelek-Karst (Hungary)

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Summary. The article is based on the results of a series of observations in the Aggtelek-Karst (northern Hungary) over several years. The plant species in the survey area, the butterfly species visiting these plants and the number of visits are recorded.

Zusammenfassung. Der Aufsatz arbeitet eine Beobachtung-Serie von mehr Jahre aus, die wir an dem Berg Aggteleki-karszt (Nordhungarien) gemacht haben. Wir haben an dem herauswählenden Gelände die Schmetterlingbesucher, beziehungsweise die Zahl der Besuchung registriert.

Résumé. L'article est basé sur les résultats d'une série d'observations faites dans la région karstique d'Aggtelek (nord de la Hongrie), étalées sur plusieurs années. Les espèces végétales de la région étudiée, les espèces de papillons visitant ces plantes et le nombre de visites sont enregistrés.

Key words: Butterflies, plants, flower visits, nectar supply, pollination, Hungary.

Introduction

Observations during several years can generate an important information about the plants of a given survey area, the composition of its butterfly fauna, as well as diversity and changes in diversity within the area. Every population is part of a community. Regarding the population of pollinators and the plants visited by them, the quality and quantity of resources (i.e. nectar producing plants) used is determined by the presence of nectar producing plants (Gonseth, 1992). Flowering plants should ensure the energy requirements of visitors. Visitors search for the most suitable sources, and their choice for a flower is dependent on many factors, such as:

- The size of the population of flowering plants. If this is not large enough there will not exist a stable pollination system (Vogel & Westerkamp, 1991);
- The colour, smell, shape etc. of the flower (Harborne, 1982);
- The position of nectary, thus the accessibility of nectar.

Methods

The study area is the Aggtelek-Karst (northern Hungary, 48° 28′ 36″ N, 20° 33′ 38″ E). The surveys were carried out between 1990 and 1994, during each July, every day between 8 a.m. and 6 p.m., because flower visitors are most active during this time (Gonseth, 1992; Olesen & Warncke, 1989). The flora of the area can be described as Polygalo-Brachypodetum and Caricetum humilis in the group of Cirsio-Brachypodion association. Dominant species in this area are for example: *Dorycnium germanicum, Coronilla varia, Teucrium chamaedrys, T. montanum, Salvia verticillata, Stachys recta, Centaurea scabiosa, Inula salicina, I. ensifolia, Carex humilis* etc. With the strating bordering, rimming (Versaumung), *Brachypodium pinnatum, Carex montana* and sprouting dicotyledons covering as much as 50% in patchwork. There are several important and protected species, such as *Dracocephalum austriacum, Adonis vernalis, Centaurea triumfetti, Polygala major, Cirsium pannonicum, Cytisus procumbens* etc. The original climax vegetation here must have been Querco-Carpinetum and Corno-Quercetum, and larger or smaller areas of these plant associations can still be found in many places in similar situations.

Results and discussion

Table 1 gives a list of selected plant species visited by butterflies in the Aggtelek-Karst. Visited plants are arranged in 5 columns by the number of contacts: the first four contain the species of the main four families while the fifth gives plant families, some species of which were rarely visited. We have examined, regarding all of the contacts, if there were annual differences in the visits to the different plant families and in the number of butterfly visits. The results show that there are significant differences in both. (Plant families: ANOVA, $F_{[4,20]} = 4.43$, $p = 0{,}01$; butterfly families: ANOVA, $F_{[4,20]} = 2.87$, $p = 0{,}01$).

Forty-one plant species were used by the butterflies in the Aggtelek-Karst. Table 2 shows the 10 most frequently visited plant species in decreasing order. At the same time these plants are the most abundant in the study area, especially the first four

Table 1. Flowering plants chosen by butterflies and burnet moths in the Aggtelek-Karst (Hungary), 1990–1994 (nomenclature of the Lepidoptera following Karsholt & Razowski, 1996)

LEPIDOPTERA	ASTERACEAE	FABACEAE	DIPSACACEAE	LABIATAE	OTHER
Erynnis tages (Linnaeus, 1758)	Carduus acanthoides 1 *Centaurea scabiosa* 12		*Dipsacus laciniatus* 1 *Scabiosa ochroleuca* 2	*Origanum vulgare* 1	
Pyrgus malvae (Linnaeus, 1758)	*Centaurea scabiosa* 3 *Inula ensifolia* 6		*Scabiosa ochroleuca* 3		
Thymelicus lineola (Ochsenheimer, 1808)	*Achillea millefolium* 1 *Carduus acaanthoides* 1 *Centaurea scabiosa* 3 *Inula ensifolia* 15	*Cytisus albus* 2	*Knautia arvensis* 1		*Linum hirsutum* 6
T. sylvestris (Poda, 1761)	*Achillea millefolium* 1 *Anthemis tinctoria* 4 *Carduus acanthoides* 4 *Centaurea scabiosa* 2 *Inula ensifolia* 9 *I. hirta* 7	*Coronilla coronata* 1 *Trifolium pratense* 1	*Knautia arvensis* 2		
Hesperia comma (Linnaeus, 1758)	*Carduus acanthoides* 26 *Centaurea scabiosa* 1		*Knautia arvensis* 4 *Scabiosa ochroleuca* 4	*Betonica officinalis* 3	
Ochlodes venata (Bremer & Grey, 1853)	*Anthemis tinctoria* 1 *Carduus acanthoides* 21 *Centaurea scabiosa* 7 *Chrysanthemum corymbosum* 1 *Cirsium arvense* 1 *Inula ensifolia* 23 *I. hirta* 3	*Cytisus albus* 3 *Medicago lupulina* 1	*Knautia arvensis* 5 *Scabiosa ochroleuca* 9	*Betonica officinalis* 4	*Convolvulus arvensis* 1
Iphiclides podalirius (Linnaeus, 1758)	*Carduus acanthoides* 25 *Centaurea scabiosa* 1				*Echium vulgare* 1 *Sambucus ebulus* 3
Leptidea sinapis (Linnaeus, 1758)		*Cytisus albus* 2 *Dorycnium germanicum* 1 *Medicago lupulina* 1 *Trifolium pratense* 1		*Origanum vulgare* 1	*Dianthus pontederae* 1
Colias alfacariensis Ribbe, 1905	*Anthemis tinctoria* 1 *Carduus acanthoides* 1 *Centaurea scabiosa* 2 *Cirsium arvense* 3 *Inula ensifolia* 2	*Trifolium pratense* 1	*Knautia arvensis* 1 *Scabiosa ochroleuca* 8		
C. hyale (Linnaeus, 1758)	*Carduus acanthoides* 9 *Cirsium arvense* 2		*Knautia arvensis* 1 *Scabiosa ochroleuca* 2		*Linum hirsutum* 1
Pieris brassicae (Linnaeus, 1758)	*Carduus acanthoides* 8			*Salvia officinalis* 1	*Chenopodium vulgare* 1 *Sambucus ebulus* 6
P. napi (Linnaeus, 1758)	*Inula hirta* 1	*Trifolium pratense* 1			*Sambucus ebulus* 3

P. rapae (Linnaeus, 1758)	*Carduus acanthoides* 8 *Centaurea scabiosa* 1 *Inula ensifolia* 4		*Knautia arvensis* 5 *Scabiosa ochroleuca* 3	*Origanum vulgare* 5	
Pontia daplidice (Linnaeus, 1758)	*Carduus acanthoides* 1 *Centaurea scabiosa* 1		*Knautia arvensis* 1 *Scabiosa ochroleuca* 3		
Lycaena dispar (Haworth, 1802)	*Cirsium arvense* 2 *Inula ensifolia* 10			*Mentha aquatica* 3	
L. virgaureae (Linnaeus, 1758)	*Achillea millefolium* 1 *Anthemis tinctoria* 8 *Chrysanthemum corymbosum* 3 *C. leucanthemum* 2 *Inula ensifolia* 12 *I. hirta* 16			*Origanum vulgare* 1	
L. tityrus (Poda, 1761)	*Inula ensifolia* 4				
Callophrys rubi (Linnaeus, 1758)		*Cytisus albus* 1		*Betonica officinalis* 2	
Satyrium w-album (Knoch, 1782)	*Centaurea scabiosa* 1			*Origanum vulgare* 7	
S. spini ([Denis & Schiffermüller], 1775)	*Achillea millefolium* 1 *Inula ensifolia* 1 *I. hirta* 2				
S. acaciae (Fabricius, 1787)	*Anthemis tinctoria* 6 *Chrysanthemum corymbosum* 2 *Inula hirta* 1				
Cupido minimus (Fuessly, 1775)	*Inula ensifolia* 1	*Medicago lupulina* 5			
C. argiades (Pallas, 1771)	*Inula ensifolia* 16				
C. alcetas (Hoffmannsegg, 1804)		*Medicago lupulina* 1		*Salvia verticillata* 1	
Plebeius argus (Linnaeus, 1758)	*Centaurea scabiosa* 2 *Inula ensifolia* 5				
P. idas (Linnaeus, 1761)	*Centaurea scabiosa* 39 *Cirsium arvense* 2 *Inula ensifolia* 1	*Cytisus austriacus* 1 *Dorycnium germanicum* 2 *Medicago lupulina* 2 *Trifolium pratense* 1		*Origanum vulgare* 1	
P. argyrognomon (Bergsträsser, 1779)	*Centaurea scabiosa* 1 *Inula ensifolia* 32				
Aricia artaxerxes (Fabricius, 1793)	*Inula ensifolia* 1	*Lotus coniculatus* 1			
Polyommatus icarus (Rottemburg, 1775)	*Anthemis tinctoria* 2 *Centaurea scabiosa* 62 *Inula ensifolia* 1	*Cytisus albus* 1 *Coronilla coronata* 2 *Dorycnium germanicum* 1 *Lotus corniculatus* 3	*Knautia arvensis* 1 *Scabiosa ochroleuca* 2	*Origanum vulgare* 1	*Dianthus pontederae* 2 *Sambucus ebulus* 2
Meleageria bellargus (Rottemburg, 1775)	*Achillea millefolium* 1 *Centaurea scabiosa* 15 *Inula ensifolia* 20			*Salvia verticillata* 1	
M. coridon (Poda, 1761)	*Achillea millefolium* 1 *Carduus acanthoides* 1 *Centaurea scabiosa* 9 *Inula ensifolia* 2		*Knautia arvensis* 2 *Scabiosa ochroleuca* 1	*Origanum vulgare* 3	
Argynnis paphia (Linnaeus, 1758)	*Carduus acanthoides* 6 *Cirsium arvense* 2 *Eupatorium cannabinum* 3		*Metha aquatica* 13	*Saambucus ebulus* 30	

LEPIDOPTERA	ASTERACEAE	FABACEAE	DIPSACACEAE	LABIATAE	OTHER
A. adippe ([Denis & Schiffermüller], 1775)	*Carduus acanthoides* 13			*Mentha aquatica* 11	*Sambucus ebulus* 11
	Centaurea scabiosa 3				
A. niobe (Linnaeus, 1758)	*Carduus acanthoides* 23				
	Centaurea scabiosa 1				
	Cirsium arvense 1				
Issoria lathonia (Linnaeus, 1758)	*Carduus acanthoides* 1		*Knautia arvensis* 1		
Brenthis ino (Rottemburg, 1775)	*Achillea millefolium* 1		*Knautia arvensis* 5		*Dianthus pontederae* 1
	Inula ensifolia 5				
	I. hirta 3				
B. hecate ([Denis & Schiffermüller], 1775)	*Achillea millefolium* 1	*Dorycnium germanicum* 9	*Knautia arvensis* 4		*Cynanchum vincetoxicum* 1
	Anthemis tinctoria 2				
	Centaurea scabiosa 4				
	Chrysanthemum corymbosum 1				
	Inula ensifolia 17				
	I. hirta 1				
Boloria dia (Linnaeus, 1767)	*Inula ensifolia* 5		*Knautia arvensis* 3		
			Scabiosa ochroleuca 2		
Melitaea didyma (Esper, 1778)	*Anthemis tinctoria* 1	*Dorycnium germanicum* 1	*Knautia arvensis* 1	*Salvia verticillata* 3	*Dianthus pontederae* 4
	Carduus acanthoides 2		*Scabiosa ochroleuca* 4		*Erysium odoratum* 1
	Centaurea scabiosa 22				*Teucrium chamaedris* 1
	Cirsium arvense				
	Inula ensifolia 28				
	I. hirta 2				
M. aurelia Nickerl, 1850	*Achillea millefolium* 1	*Coronilla varia* 3	*Knautia arvensis* 11	*Salvia verticillata* 5	*Cynanchum vincetoxicum* 6
	Centaurea scabiosa 6	*Dorycnium germanicum* 20		*Dianthus pontederae* 2	
	Chrysanthemum corymbosum 2	*Trifolium pannonicum* 9			
	Inula ensifolia 64				
	I. hirta 9				
M. britomartis Assmann, 1847	*Achillea millefolium* 1	*Dorycnium germanicum* 12	*Knautia arvensis* 9		*Cynanchum vincetoxicum* 1
	Centaurea scabiosa 6	*Trifolium rubens* 1	*Scabiosa ochroleuca* 1		*Dianthus pontederae* 1
	Chrysanthemum corymbosum 3				
	Cirsium arvense 2				
	Inula ensifolia 47				
	I. hirta 4				
M. athalia (Rottemburg, 1775)	*Achillea millefolium* 3	*Coronilla coronata* 4	*Knautia arvensis* 16	*Origanum vulgare* 4	*Cynanchum vincetoxicum* 2
	Anthemis tinctoria 4	*Dorycnium germanicum* 7	*Scabiosa ochroleuca* 1	*Salvia verticillata* 3	
	Centaurea scabiosa 11	*Trifolium pannonicum* 10			
	Chrysanthemum corymbosum 5				
	Cirsium arvense 3				
	Inula ensifolia 78				
	I. hirta 31				
Lopinga achine (Scopoli, 1763)	*Centaurea scabiosa* 1			*Mentha aquatica* 12	
	Inula ensifolia 6				

Coenonympha arcania (Linnaeus, 1761)	*Centaurea scabiosa* 4 *Cirsium arvense* 14 *Inula ensifolia* 41	*Medicago falcata* 1 *Trifolium rubens* 2		*Betonica officinalis* 3 *Mentha aquatica* 9	
C. glycerion (Borkhausen, 1788)	*Centaurea scabiosa* 21 *Cirsium arvense* 1 *Inula ensifolia* 15	*Dorycnium germanicum* 5	*Knautia arvensis* 1	*Salvia verticillata* 1	
Coenonympha sp.	*Inula ensifolia* 1		*Scabiosa ochroleuca* 1		*Dianthus pontederae* 2
C. pamphilus (Linnaeus, 1758)	*Cirsium arvense* 9			*Betonica officinalis* 2	
Aphantopus hyperantus (Linnaeus, 1758)	*Centaurea scabiosa* 1 *Inula ensifolia* 10		*Knautia arvensis* 2		
Maniola jurtina (Linnaeus, 1758)	*Achillea millefolium* 1 *Anthemis tinctoria* 1 *Carduus acanthoides* 104 *Centaurea scabiosa* 161 *Cirsium arvense* 33 *Chrysanthemum corymbosum* 1 *Inula ensifolia* 286 *I. salicina* 10	*Coronilla coronata* 2 *Dorycnium germanicum* 1 *Trifolium pratense* 4	*Knautia arvensis* 45 *Scabiosa ochroleuca* 12	*Betonica officinalis* 5 *Mentha aquatica* 15 *Origanum vulgare* 9 *Salvia verticillata* 1	*Convolvulus arvensis* 1 *Dianthus pontederae* 8 *Helianthemum ovatum* 1 *Sambucus ebulus* 25
Melanargia galathea (Linnaeus, 1758)	*Achillea millefolium* 1 *Carduus acanthoides* 22 *Centaurea scabiosa* 85 *Cirsium arvense* 4 *Inula ensifolia* 30 *I. hirta* 4	*Coronilla varia* 5 *Cytisus albus* 3 *Dorycnium germanicum* 3 *Trifolium pratense* 4	*Knautia arvensis* 16 *Scabiosa ochroleuca* 2	*Veronica officinalis* 1	*Cynanchum vincetoxicum* 1 *Dianthus pontederae* 9
Minois dryas (Scopoli, 1763)	*Carduus acanthoides* 8 *Centaurea scabiosa* 1 *Cirsium arvense* 4 *Inula ensifolia* 16			*Mentha aquatica* 1	*Sambucus ebulus* 2
Amata phegea (Linnaeus, 1758)	*Carduus acanthoides* 3 *Centaurea scabiosa* 3 *Inula ensifolia* 1			*Origanum vulgare* 1	
Zygaena purpuralis (Brünnich, 1763)	*Carduus acanthoides* 2 *Centaurea scabiosa* 26 *Cirsium arvense* 1		*Knautia arvensis* 2	*Origanum vulgare* 1	*Dianthus pontederae* 1
Z. carniolica (Scopoli, 1763)	*Carduus acanthoides* 1 *Centaurea scabiosa* 60 *Cirsium arvense* 2 *Inula ensifolia* 2		*Knautia arvensis* 15 *Scabiosa ochroleuca* 5	*Salvia verticillata* 2	
Z. viciae ([Denis & Schiffermüller], 1775)	*Achillea millefolium* 2 *Centaurea scabiosa* 2 *Inula ensifolia* 2		*Knautia arvensis* 1	*Salvia verticillata* 1	
Z. filipendulae (Linnaeus, 1758)	*Carduus acanthoides* 25 *Centaurea scabiosa* 40 *Cirsium arvense* 6 *Inula ensifolia* 7		*Knautia arvensis* 45 *Scabiosa ochroleuca* 8	*Betonica officinalis* 2 *Origanum vulgare* 2	*Dianthus pontederae* 1
Z. lonicerae (Scheven, 1777)	*Centaurea scabiosa* 1 *Chrysanthemum corymbosum* 1 *Inula ensifolia* 2		*Knautia arvensis* 3	*Betonica officinalis* 3	*Dianthus pontederae* 1

Table 2. Relative frequencies of visits on the different plant species (prf) and number of visiting butterfly species / visits on the different plant species (pv/vp)

Most frequently visited plants	prf	pv/vp
1. *Inula ensifolia*	0.33	0.045
2. *Centaurea scabiosa*	0.257	0.058
3. *Carduus acanthoides*	0.129	0.075
4. *Knautia arvensis*	0.0826	0.133
5. *Cirsium arvense*	0.0375	0.206
6. *Inula hirta*	0.0342	0.155
7. *Sambucus ebulus*	0.0334	0.097
8. *Scabiosa ochroleuca*	0.0297	0.26
9. *Mentha aqutica*	0.026	0.109
10. *Dorycnium germanicum*	0.0252	0.177

(*Inula ensifolia, Centaurea scabiosa, Carduus acanthoides, Knautia arvensis*). This fact has a significant effect on food searching behaviour of butterflies. Colours of the plants mentioned above are mostly lilac or purple and, more rarely, yellow or white. These data agree with our knowledge concerning the colour selectivity of insects (Harborne, 1982; Jolivet, 1986). Besides, these plants are robust and tall, which could also have importance for food-recognition of insects (Porter *et al.*, 1992). Table 2 shows the relative frequencies of visits on the different plant species (prf) and the ratio of the number of the visiting butterflies to the number of the visits on the different plant species. These values (pv/vp) show how many butterfly species were responsible for the contacts. Thus, for example, on *Cirsium arvense* and *Scabiosa ochroleuca* fewer visits were paid by more butterfly species, and on the first three plant species more visits were paid by fewer butterfly species.

The family Asteraceae dominated throughout the survey period (over 50% in every year), especially in 1991 (87.4%) and 1994 (79.46%). This is the most species-rich plant group — they are present on almost all continents and habitats. Thus, they provide enough food for numerous flower visitors. Their lack or decrease in the area would substantially affect species composition of the insects.

Changes in flower visits were identified at family level between 1990 and 1994. In 1990, species of Nymphalinae were the main flower visitors while in 1994, by a gradual process, the Satyrinae

had become main visitors. Regarding the vegetation of the study area the main feature is the expansion of *Brachypodium pinnatum*, which surpasses that of important nectar-producing plants. This phenomenon can provide explanation for the dominance changes in flower visits mentioned above. Butterfly-indication shows clearly the absence or decrease in those plant species that are their main nectar sources. With some exceptions, nectar plant specialisation is not characteristic for butterflies. Although the Asteraceae are the preferred plant family among butterflies, this does not mean that other plant families are not visited by them. The preference for Asteraceae lies in the shape of their inflorescence. The heads of their flowers serve as an appropriate roost for butterflies, and after landing they only have to reach out for nectar. As flower heads (capitulum) of the Asteraceae contain many flowers, the amount of nectar is enough to satisfy the appetite of visitors. Nectary is usually present at the base of the flower, at the base of the style or between the pistil and stamen. The shape of butterflies prevents them from climbing into the flower as in the case of bees.

Regarding the butterfly species, the main visitor was *Maniola jurtina* (on 21 plant species 726 contacts were registered). Its food plant list observed by us is more or less the same as previously indicated in the literature (Gonseth, 1992; Weidemann, 1995). Ebert & Rennwald (1991) have listed 65 out of 164 plant species known to occur in Baden-Württemberg. In contrast to the Meadow Brown, the Lycaenidae pay the fewest visits. This supports, on one hand, a hypothesis that the quality of the vegetation in the study area has an influence on the presence of butterflies. On the other hand, it is well known that the Lycaenidae prefer fewer nectar-producing plants. Most species of this butterfly family occupy a large range and can be found in many kinds of plant associations. In contrast to this, there are many species among the Lycaenidae and Nymphalinae that are more confined to plant associations. Thus, the disappearance of important food sources could affect their distribution pattern. Choice of food plants by butterflies depends on different factors. Thus, for example, *Melanargia galathea* chooses plants with lilac or purple flowers, species of Papilionidae (*Iphiclides podalirius*) and Nymphalinae (*Argynnis paphia, A. adippe, A. niobe, Issoria*

lathonia) prefer robust plants overhanging the vegetation cover in their habitat (*Centaurea scabiosa, Carduus acanthoides*, etc.).

Conclusions

Several plant species can be ranked as food plants (nectar sources) of butterflies. An important factor is the availability of plants in a given area. The continuous — year by year — presence of these plant species also has certain effects on the pollinator-population. We cannot find a unified methodology to explain the food plant choice of butterflies. Depending on the circumstances, these insects prefer the different food sources. That is why it is so important to take into consideration their indicative role, they can be pollinators only when the food plant is present.

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Wing deformation in an isolated Carpathian population of *Parnassius apollo* (Papilionidae: Parnassiinae)

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Summary. The last native population of *Parnassius apollo* (Linnaeus, 1758) in the Pieniny Mts. (Polish Carpathians) has been isolated for at least 20 years. In captive breeding, individuals with crippled or even missing wings were frequent. Crippled individuals were also observed in the field. However, while in the field only deformed males were found, in captivity the number of deformed females was about twice that of deformed males. Some genetic models for this situation are discussed.

Zusammenfassung. Die letzte Population von *Parnassius apollo* (Linnaeus, 1758) im Pienin (Karpathen, Poland) ist seit mindestens 20 Jahren genetisch isoliert. In einer Gefangenschaftszucht traten zahlreich Individuen mit verkrüppelten oder sogar völlig fehlenden Flügeln auf. Das Phänomen wurde auch im Freiland registriert. Während im Freiland jedoch nur deformierte Männchen beobachtet wurden, sind in der Zucht Weibchen doppelt so häufig deformiert wie Männchen. Hierzu werden einige genetische Modelle diskutiert.

Résumé. La dernière population autochtone de *Parnassius apollo* (Linnaeus, 1758) aux Monts Pieniny (Carpathes polonaises) a été isolée depuis au moins 20 ans. Lors d'un élevage en captivité, des individus à ailes malformées, voire même totalement manquantes, étaient fréquents. Des individus malformés furent également observés dans la nature. Toutefois, alors qu'à l'état sauvage seulement des mâles déformés ont été trouvés, en captivité le nombre de femelles déformées était le double de celui des mâles. Quelques modèles génétiques susceptibles d'expliquer cette situation sont discutés.

Key words: Lepidoptera, *Parnassius*, populations, teratology, genetics, Poland.

In the course of restoring a *Parnassius apollo* (Linnaeus, 1758) metapopulation in the Pieniny Mts. (Polish Carpathians) the last native population of that species was investigated (Witkowski & Adamski, 1996; Witkowski *et al.*, 1993). This population has been isolated for at least 20 years. At the beginning of the nineties its size did not exceed 20–30 individuals; hence, one may suppose

that the long-term isolation and inbreeding connected with the small size of the population has lead to genetic degradation manifested in certain phenotypic characters.

Recovery measures on the population have included captive breeding based on individuals originating from that last isolated population. In captivity, a few phenotypic characters indicating genetic degradation were noticed (Allendorf & Leary, 1986; Chen, 1971):

- high mortality of pupae (>50% individuals) (Witkowski *et al.*, 1993),
- appearance of individuals with changed pattern of wing veins (Witkowski *et al.*, l.c.),
- considerable variation of egg hatching (with statistically significant difference between lines) (Witkowski *et al.*, l.c.),
- appearance of individuals with partially reduced or even vestigial wings (Witkowski *et al.*, l.c.).

As this last character was observed in both captive and wild populations, and has not appeared in the literature on *P. apollo* (recently such a phenomenon was reported from Turkey (Kovanci *et al.*, 1996)), it seems proper to present this question in detail.

Captive breeding was established in 1991, based on L3 and L4 larvae collected in the field. The second year commenced with eggs laid by two captive females and was completed with eggs obtained from two other females in the field. In that year the first individuals with deformed wings were observed in captivity. For experimental purposes, one wingless female was mated with a normal male. It appeared that wingless females were able to copulate, and eggs laid by them did not differ from the other females.

In two successive years (1993 and 1994), despite supplementary breeding using material from wild females, both mortality of captive population and fraction of wingless individuals increased (Budzik, unpubl. ms). In 1993, the fraction of wingless individuals amounted to about 16% of the captive population (Table 1).

The handicapped individuals form three groups (fig. 1). The first comprises wingless individuals. The second are individuals with deformed wings; these were unable to complete development (wing expansion); these wings are stuck together and are severely

creased. The third group includes individuals that almost completed wing development (attained normal expansion) but whose wings were nevertheless creased. It is worthy of notice that single handicapped individuals like these were observed each year in the wild population, too. They were males that tried to fly, hopping? in long leaps much as cockchafers (Cicindelidae) do. Females in the wild were much less active and no handicapped individuals of this sex were found.

In 1994, the captive population was reinforced with wild individuals from a larger neighbouring population (Slovakian part of the Pieniny Mts.) and in subsequent years handicapped individuals appeared only sporadically.

In 1993, in the captive breeding population (before reinforcing it with the Slovakian individuals), a proportion of normally developed individuals to handicapped ones was as 601 to 175 (Table 1). The proportions of sexes among handicapped individuals were as follows:

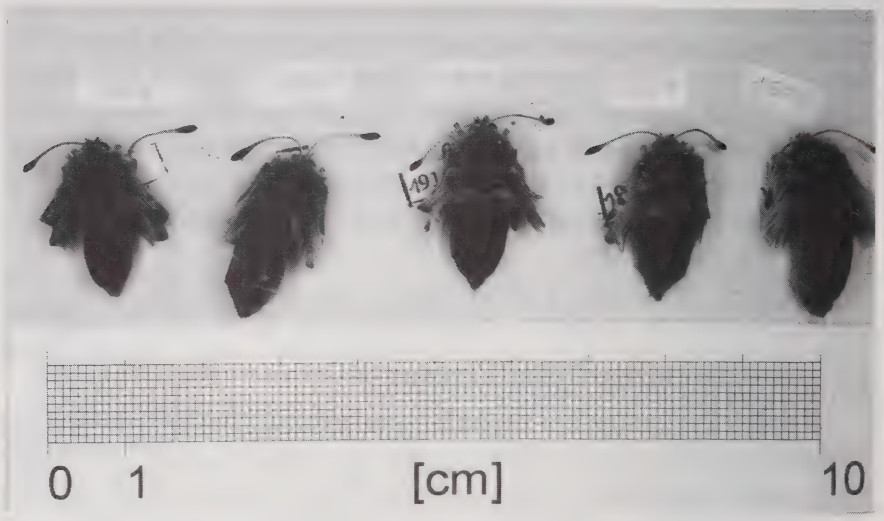
- group 1 (wingless individuals) — 74 females and 24 males;
- group 2 (deformed wings, unable to fly) and group 3 (deformed wings, able to make short leaps) — 29 males and 24 females (table 1).

These proportions point to some statistical regularities:

- In the group of wingless individuals the sex ratio markedly differed from 1:1 (Chi-square test for 2×2 2:2 tables = 4.27, $p < 0.0288$, H_0 = sex ratio not different from 1:1 was rejected).
- A difference between the sex ratio in wingless individuals and the sex ratio in individuals with deformed wings is also statistically significant (Chi-Square test = 4.81, $p = 0.0282$, H_0 = equivalent sex ratio in both cases of 1:1 was rejected).

Table 1. Number and percentages of normal and handicapped individuals of *Parnassius apollo* (Pieniny Mts. race) hatched during captive breeding in 1993

	Normal	Damaged	Wingless
	number of individuals		
male	286	29	45
female	315	24	77
	percentages		
male	79	8	13
female	76	6	19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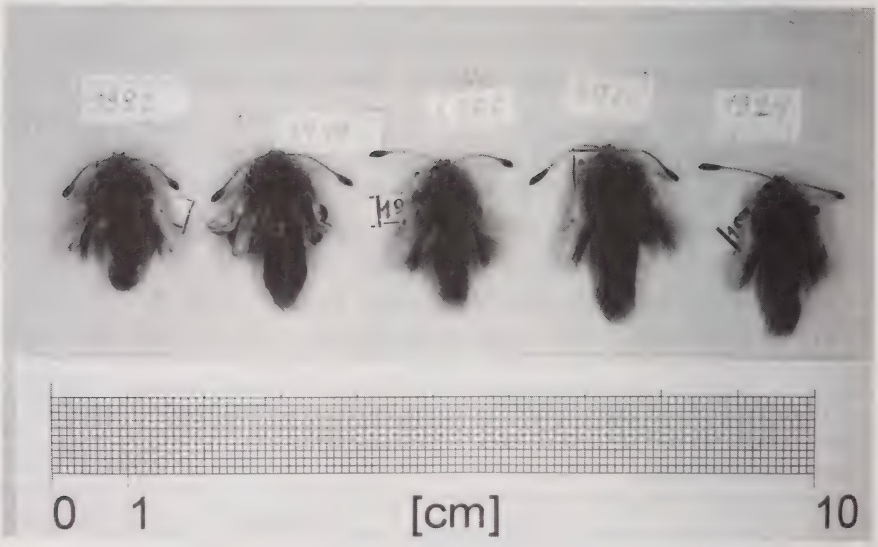
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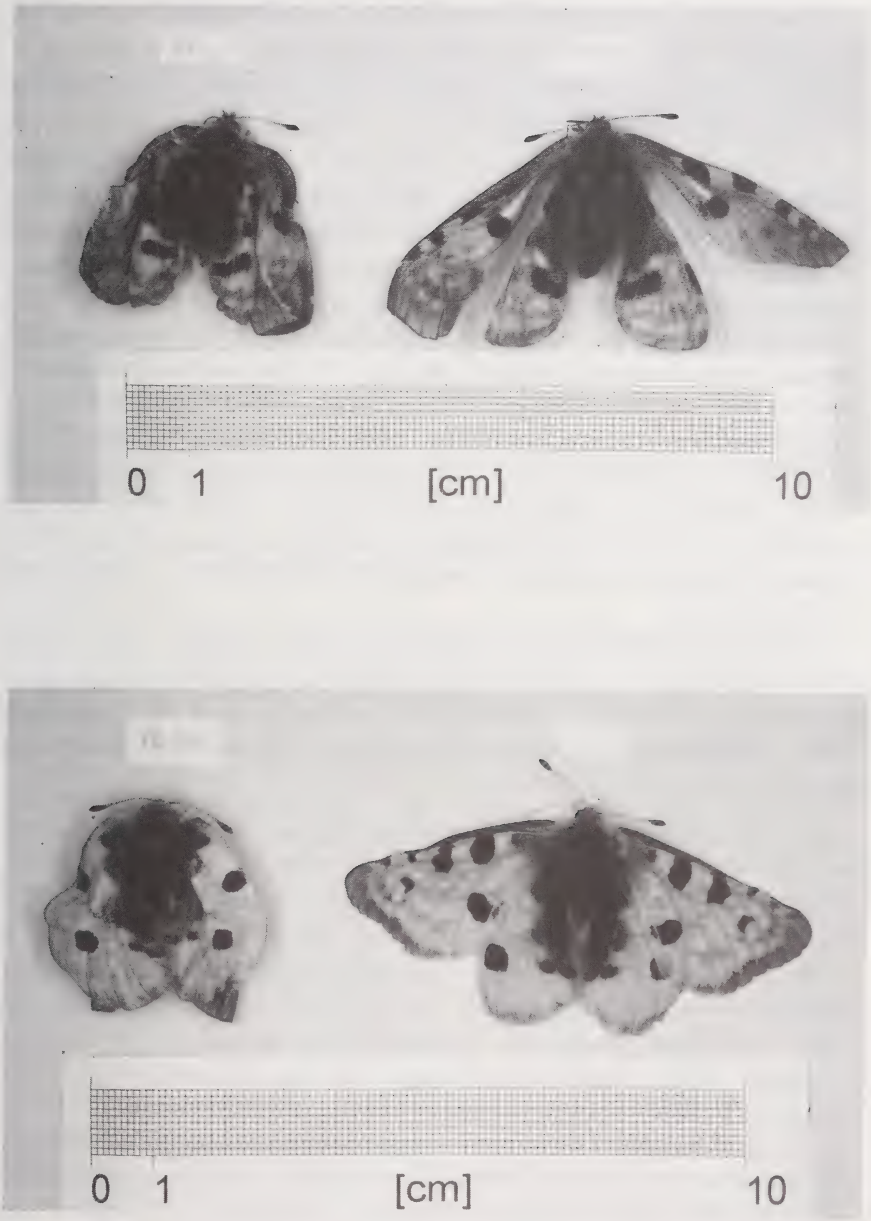

Fig. 1. Wingless (left) and deformed (right) individuals of *Parnassius apollo* during captive breeding of a restored metapopulation in the Pieniny Mts. (Polish Carpathians) (upper : females ; lower : males).

Since the fraction of handicapped individuals in captive population is ponderable, a hypothesis that the deformation of wings has a genetic background is very probable. Theoretically we may expect two possibilities:

1. *A quantitative polygenic inheritance.* Individuals with partially deformed wings were in captive breeding less numerous than completely wingless individuals. This suggests that the degree of wing development is not a quantitative character, which may assume values from the full development to the complete lack of wings. In such a case the wingless forms (the extreme morph) would occur least numerously or, at low frequencies of alleles, they would not be observed at all (Fisher, 1930). Wingless forms should occur with low frequency even in the case of significant differences in natural selection pressure on males and females.

2. *A qualitative single-locus inheritance.* In this situation we assume that the lack of wings is a qualitative character, but that defective wing expansion is a separate phenomenon regulated in a different way.

Another problem is the sex ratio of wingless individuals, which approximates 2:1 in favour of females (Chi-square = 0.34, $p = 0.56$, H_0 = sex ratio not different from 2:1 was not rejected). This phenomenon may be caused by one of the following alternatives:

A. The locus responsible for the wingless condition is located on the sex chromosome X. In this case a most fraction of phenotypes in which this locus becomes manifested should be expected in the heterogametic sex i.e. females (Haldane's rule).

B. Expression of the allele for "winglessness" is facilitated in females depending on genetic background. In this case the sex ratio diverging from 1:1 indicates the operation of natural selection which leads to differences in the expression of "winglessness" alleles between males (for which flightlessness is always a loss) and females (for which it may sometimes be an advantage) (Witkowski & Adamski, 1996). The fact that wingless individuals are not eliminated suggests that this character is "treated" by natural selection as at least a neutral mutation (Witkowski & Adamski, 1996).

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Book reviews • Buchbesprechungen • Analyses

Maso, A. & Pijoan, M.: Observar Mariposas.
17 × 28.5 cm, 319 pp., text in Spanish, hardback. Published by Editorial Planeta S.A., Barcelona, 1997. ISBN 84-08-02072-2. To be ordered from: Editorial Planeta S.A., Córcega Str., 273–279, E-08008 Barcelona, Spain. Price: Pesetas 5.300.

The work entitled "Observing butterflies and moths" begins with a prologue by Dr. Richard S. Peigler, followed by a useful introduction where the authors explain the aim of the book and reveal how it has been structured. It consists of 62 independent subjects, that can be read independently from one another, hence it is not necessary to begin with subject 1 to finish with subject 62. They are included within five thematic chapters as follows.

Chapter 1, "Understanding butterflies and moths", includes nine subjects. Here the authors introduce the layman into the world of Arthropoda, Insecta and finally Lepidoptera. The species concept, the evolution and origin of the Lepidoptera, their special senses and vision, their wing patterns, colours and wing scales are also considered in this first chapter.
Chapter 2, "The living cycle", includes nine subjects. In this chapter, the four stages of a lepidopteran life cycle — from egg to adult — are considered as well as some of the special adaptations they show to cope with the different environments they live in. Other aspects dealt with in this chapter are sexual di- or polymorphism, gynandromorphism, seasonal polyphenism and diapause.
Chapter 3, "The Lepidoptera and their environment", includes 12 subjects, all dealing with the ecology s.l. of the Lepidoptera. Subjects as food chains, food resources, predators and parasites, pests, dispersal and conservation of endangered species are dealt with in this chapter.
Chapter 4, "Defense and Behaviour", includes 16 subjects, all concerned, as the title indicates, with the different defense systems and behavioural patterns shown by the Lepidoptera. Subjects as larval and adult camouflage, aposematic coloration, Müllerian and Batesian mimicry, female and male sex pheromones, flight mechanism and migration are dealt with in this chapter.
Chapter 5, "Lepidoptera and man", which also includes 16 subjects, deals with aspects related to the long-lasting relationship between man and Lepidoptera. Lives of famous writers and entomologists, from Aristotle to Niko Tinbergen, through Carolus Linnaeus, Alfred Russell Wallace, Charles Darwin, Jean-Henry Fabre, Vladimir Nabokov and Ernst Jünger, are briefly narrated in this wonderful chapter, showing the fascination these colourful and graceful insects arose in all these sensible great men. Other aspects as the presence of the Lepidoptera in all manifestations of the Arts, ancient and modern, as well as in Western, Eastern and Mexican mythology, are considered

here. Two of the subjects of this Chapter are of special interest: one is devoted to the production of silk and the historical Silk Way between China and Europe; another analizes the importance that the larvae of some Lepidoptera have as a food resource for some people, mostly in Africa and Asia. The book ends with a basic Bibliography, a useful thematic index and the acknowledgements.

It is a very good vulgarizing work dealing with the world of the Lepidoptera, mostly addressed to children and non-lepidopterists, though amateur and professional lepidopterists will also enjoy it. For that reason it was conceived in a very didactic way. It is extensively and superbly illustrated with colour photographs, which help understanding the meaning of what is stated in the text.

The text, though kept as simple as possible, has been written with scientific rigour and, having been checked by specialists on the different subjects dealt with, mistakes are kept to a minimum, which is important for such a work. Some minor ones, though, have slipped into the captions of the photographs, which no doubt is not the authors' fault. For example, on page 151, there are two photographs showing the nymphalid *Erebia pandrose*; the top one shows the butterfly upperside, the bottom one shows its underside. However, the caption states that the top photograph shows the papilionid *Parnassius apollo*. Also on page 153, the bottom photograph is supposed to illustrate a larva of the saturniid moth *Aglia tau*, where in fact it is showing a dead caterpillar of a nymphalid butterfly belonging to the genus *Apatura* (*ilia* or *iris*). Also, on page 159, dealing with tropical rainforests, the text makes reference to CITES protected species and quotes the birdwings (genus *Ornithoptera*) as an example. However the butterfly illustrated which accompanies this text is not an *Ornithoptera* representative but *Teinopalpus imperialis*, another papilionid protected by CITES. In this last case it would have been more appropriate to illustrate one *Ornithoptera* species instead of *Teinopalpus* as children and non-lepidopterists might be led to assume the illustrated one is an *Ornithoptera*.

In sum, this book is well conceived and structured, very didactic, superbly illustrated and probably the best vulgarizing work on Lepidoptera published so far in Spain. Translation into other languages would help to fully appreciate its value. The Publisher, Editorial Planeta, should also be congratulated for the high quality reproduction of photographs and text as well as for the editorial work, all contributing to a fine product that will certainly help beginners to discover the fascinating world of butterflies and moths.

Víctor Sarto i Monteys

Fibiger, Michael: Noctuidae Europaeae. Volume 3. Noctuinae III.
22.2 × 29.2 cm, 418 pp., hardback. Published by Entomological Press, Sor, 1997. ISBN 87–89430–05–0. To be ordered from: Apollo Books, Kirkeby Sand

19, DK-5771 Stenstrup, Denmark. Price: DKK 890,- excl. postage (10% discount to subscribers to the whole series, Vol. 1–12).

The present bilingual book (in English and French) is the third — and last, at least for the moment — in a series devoted to the noctuid subfamily Noctuinae, within the more ambitious series Noctuidae Europaeae, which deals with all European Noctuidae. The previous two parts (Fibiger, 1990; 1993) dealt with revisions and analyses of taxonomy (morphology, mainly of the imagines), nomenclature, bionomics (partly) and the distribution of the species and subspecies of European Noctuinae.

This third book deals primarily with the morphology of the male and female genitalia of all the European species of Noctuinae, totalling 262 known species in September 1996. The number of European Noctuinae species has increased considerably since Hartig & Heinicke published their list in 1974 (they listed 186 species). Since the publication of the first two volumes on Noctuinae, five species have been transferred from Noctuinae to Ipimorphinae (Amphipyrinae) as follows: *Actinotia polyodon, A.radiosa, Chloantha hyperici, Mesogona acetosellae* and *M.oxalina*. For the sake of consistency between volumes 1, 2 and 3, the genitalia of all five species are described and illustrated in the present volume.

The book is organized as follows: it begins with a preface and acknowledgements, followed by a short introduction where the author, among other matters, explains why photographs instead of drawings have been chosen to illustrate the genitalia. A very useful section is devoted to the technique used for making genitalia preparations (male and female), including how to evert the male vesica from the aedeagus. Follows a very useful taxonomic and nomenclatural summary. The achievements of Fibiger's work are impressive: one lectotype designation for *Euxoa foeda* (Lederer, 1855); two newly described genera, *Basistriga* and *Albocosta*; four newly described species, *Euxoa penelope, Euxoa montivaga, Yigoga insula* and *Yigoga soror*; five newly described subspecies; nine existing taxa raised to species level and three raised to subspecies level; 76 new synonyms, nomina nuda, revised synonyms; 24 new combinations. Then comes the systematic part. Before getting into the different Noctuinae genera, Fibiger defends the monophyly of the subfamily, quoting ten character states. He also presents very convincing arguments (at least to me) to reject most, if not all, of the new nominal taxa published by Beck (1996). The step taken by Fibiger here is important. One might agree or disagree with the systematic order adopted by a particular author, but in Science solid arguments against or in favour of determined points of view should always be clearly presented so that followers can decide whom to follow. Ego should be left aside, at least when writing a scientific text. As usual, the test of time will always have the last word. There are also some interesting considerations on the species-subspecies dilemma, accompanied by a definition of these terms as used by the author. After that, the proper systematic part begins, dealing with the 43 genera of European Noctuinae plus the genera *Mesogona, Actinotia* and *Chloantha* which, as explained

above, have been transferred to the Ipimorphinae. For each genus, there is an introductory section which includes useful diagnostic features along with drawings of (for the genus) generalized male genitalia, male everted vesica and female genitalia. Then comes a classification of the European species-groups and, when applicable, of the subgenera within the genus. Finally, the European species are dealt with one by one, including taxonomic notes when necessary and numerical references to male armature, vesica and female genitalia to be found on the numerous photographic plates; also, comments about the genitalic differences from other closely related species are brought forth if needed.
The photographic plates, which take half the book, show the male genitalia, the aedeagus with everted vesica and the female genitalia of all 262 European species (and some subspecies) of Noctuinae (plus those of the Ipimorphinae *Mesogona oxalina* and *M. acetosellae, Actinotia polyodon* and *A. radiosa*, and *Chloantha hyperici*).
The book ends with a Corrigenda to Noctuidae Europaeae, vol. 1 and 2, a specialized Bibliography and a useful Index.

The order brought into the subfamily by M. Fibiger's work was very much needed and no doubt will be appreciated for a long time. As appears unavoidable in such a huge work, some minor mistakes have slipped into it, for example, on page 15 one reads "The aedeagus is transferred to absolute isopropanol and injected from the anterior end (through ductus seminalis) with isopropanol ...". Obviously the injection should take place through the ductus ejaculatorius, not through the ductus seminalis. Also some numerical references given to genitalic preparations in the text do not coincide with their corresponding photographic plates. For example, on page 34, the male armature for *Euxoa lidia* is gen. prep. 2058. However, when going to the corresponding photographic plate, the number does not coincide (it is 11369 instead of the expected 2058).
A comment on the presence of species in "Europe" is as follows. Fibiger states that *Euxoa beatissima* Rebel, 1913, and *Euxoa canariensis* Rebel, 1902, "have never been found in Europe", so they have not been included in his book that deals with European Noctuinae, although other authors, e.g. Beck, include them in their European lists. It is necessary, however, to point out that both species are found on the Canary islands, which politically belong to Spain and thus geopolitically to "Europe". Certainly Fibiger, in the first book of the series, sets his limits of biogeographical "Europe", including the Azores and Madeira but not the Canary islands. In that respect I agree with Fibiger's biogeographical view, but other authors might consider the fauna of the Canary islands as European too, so the sentence quoted above should have been used more carefully.

In sum, this book by the Danish author Michael Fibiger succesfully closes the study of one of the most difficult subfamilies within the Noctuidae, the Noctuinae. For the first time ever in Europe, a detailed comparative study of the male and female genitalia of an entire subfamily, including illustrations

of the everted vesica, has been published. This book, together with volume 1 and 2, is a must for researchers working on noctuid moths, a very significant group, both from the point of view of basic phylogenetic studies and of its economic importance, as several species are serious pests of agricultural crops.

Víctor Sarto i Monteys

Pamperis, Lazaros N.: The Butterflies of Greece.
22 × 29.7 cm, xii + 559 pp., 44 text figures (11 in colour), 8 tables (listed as "plates"), 129 distribution maps, 234 diagrams, 1174 colour photographs, hardback. Published by A. Bastas-D. Plessas Graphic Arts S.A., Athens, September 1997. ISBN 960–7418–20–4. To be ordered from: Bastas-Plessas Publications, Herons Str. 21, GR-104 42 Athens, Greece, Tel.: (00 31)51.35.325–7; fax; 51.39.115; e-mail: basphe hol.gr. http://www.hol.gr/business/basple/. Price: GRD 30.000, excl. postage.

Greece has one of the richest butterfly faunas in whole Europe, and it appears therefore quite surprising that no comprehensive book dealing with it had been published so far. The title of the present work suggests that this gap is filled at last and, at a first glance, the result seems quite impressive indeed. The numerous beautiful photographs, showing living butterflies in their natural environment, and sometimes the early stages as well, contribute largely to this effect. For this achievement, the author deserves respect. The text, however, is absolutely substandard. Scientific names are published without author's name and year of publication, nowhere printed in italics and, the more, an out-dated nomenclature is used (e.g. "*Agrodiaetus*" *escheri, amanda* and *thersites*, "*Plebicula*" *dorylas*, "*Lysandra*" *coridon, philippi* and *bellargus*, "*Erebia*" *phegea*). The placing of some taxa is also questionable, e.g. of *Satyrium ledereri* between *Zizeeria karsandra* and *Lampides boeticus*! Some misspellings (e.g. *Hipparchia cristenseni* [recte *christenseni*] on p. 340; *Maniola jurdina* [recte *jurtina*] on pp. 394–395) are quite disturbing, as are some species names used (e.g. *Elphinstonia charlonia* [sic!] instead of *E. penia*: it is the latter species that occurs in Greece, the former one being restricted to Spain, North Africa and parts of the Near East; *Pseudochazara cingovskii* instead of *P. mniszechii*: the former taxon does not occur in Greece, being restricted to the Prilep area in ex-Yugoslav Macedonia, the latter is represented in Greece by subspecies *tisiphone*, a name which is not mentioned anywhere at all). Some identifications appear questionable (e.g. *Pseudochazara amymone* on p. 351 which, the more, is most probably a male and not a female as stated in the text).

The author is clearly a nature lover and without any doubt his intentions are sincere. His hostile attitude towards collecting is, however, unjustifiable and even counterproductive. The author seems to forget that the current knowledge on which he has based his field trips in order to obtain his data, was gathered by a number of entomologists who collected representative samples of each nominal taxon for comparative purpose as well as for

identification (it is, for instance, impossible to distinguish some taxa without examination of some structural characters, i.e. mainly the genitalia as in e.g. the genus *Hipparchia*). The external features illustrated by the author and supposed to help in the identification of "difficult" taxa (e.g. the "brown *Agrodiaetus*" on p. 200, *Hipparchia* on p. 334, *Pseudochazara* on pp. 348–349 and *Pyrgus* and related genera on pp. 440–441) appear of no use. Some taxa have been identified (mainly) following electrophoretic investigations (e.g. *Pontia edusa* (referred to as *daplidice* in the present work), *Maniola chia*), a fact that seems to have escaped the author's attention. The reviewer would be much interested to know on which evidence the occurrence and distribution of *Agrodiaetus ripartii* in Greece is based (the postulated difference in the white streak on unh between *ripartii* and *pelopi* does not appear very convincing, compare illustrations on pp. 201 and 204–205). Karyological studies (for which one does, indeed, have to kill some specimens) would seem much more reliable.

In many instances, the conservation status of nominal taxa is indicated as rare, because of "collectors' interest", a highly ludicrous statement for taxa like, for instance, *Pseudochazara amymone, Maniola halicarnassus* and *M. megala*, that have probably ever been collected in Greece by only one or two people so far! The reviewer further fails to see how species like *Parnassius mnemosyne, Hamearis lucina*, "*Quercusia*" *quercus*, "*Strymonidia*" *w-album* and *pruni*, "*Eumedonia*" *eumedon*, "*Lycaeides*" *argyrognomon* and *Erebia euryale*, to name but a few, would be threatened by collectors' interest, being widespread at least all over Central Europe.

The photographs of butterflies and biotopes are never accompanied by any precise data as to the locality or even general area of origin, thus undoing any scientific value to these observations. No voucher specimens are at hand to confirm some questionable reports and the reviewer puts question marks to many dots on the distribution maps the author was willing to produce. One single example will illustrate this. On p. 100, a distribution map of "*Nordmannia*" *ilicis* includes the island of Ródos (Rhodes) among the available records. The reviewer has never been able to observe this species on that island, neither did any of his predecessors since lepidopterological explorations started there. It would have been very useful and interesting had Pamperis collected — be it one single — voucher specimen to substantiate this record. Hence on present evidence this record has to be dismissed as unconfirmed. Another case, perhaps the most exciting one dealt with in this book, is that of *Zizeeria karsandra*, which the author reports from "AEG" and "CRE". This species had previously been mentioned in literature (see Olivier, 1993. The butterflies of the Greek island of Ródos (...): 192 and references mentioned therein for a review): it would have been of the greatest value had Pamperis published from where his original data have been gathered (the photographs prove beyond doubt that these specimens are indeed *Z. karsandra* and that the butterfly thus is a true resident of the Greek butterfly fauna). "Collectors' interest" cannot be accounted for as a potential threat, as virtually nobody

ever observed this butterfly on any Greek island so far. On the contrary, habitat destruction could very conceivably cause its extinction in this country, if the butterfly appears to live in only one or a few localities. Without any more precise data it appears simply impossible to start any conservation programme on this issue!

The real threats to the butterfly fauna of Greece (habitat destruction, overgrazing by goats and sheep, large-scale burning of forest and maquis, destruction of natural coastal and lowland habitats for the building of touristic accomodation, ...) are given only marginal attention. The "collector", who appears by the way to be the only really competent specialist to judge on matters of taxonomy, distribution, ecology and, ultimately, conservation, is accused of being the main cause of decline of butterflies (which, for the time being, appears fortunately enough to be minor in comparison to what is currently happening in the industrialised countries of northwestern Europe). Such an attitude could lend support to politicians and governmental (including so-called "conservationist") bodies to instore a law imposing a total ban on collecting, as is already the case in Germany and Spain, two countries where, ironically (is this coincidence?), there is a flourishing trade in butterflies!

The author missed a unique opportunity to achieve a real great work, in not having consulted a qualified team of "collectors" [recte entomologists], who could have reviewed the manuscript thoroughly before it went to press. Many erroneous, unpleasant and largely unjustified statements could thus have been prevented from appearing into the public domain.

To sum up in short, the butterfly illustrated on the cover page symbolizes very well the content of this book: the specimen is a male *Lycaena candens*. The author, however, refers to it as "*Palaeochrysophanus*" *hippothoe*, a species that does not even occur in Greece, having its southern distribution limit on the Balkans in Bosnia. The most obvious difference between both species resides in the male genitalia (UV reflectance photography is an additional aid). Had nobody ever dissected any specimen, we would still be ignorant of the very fact that these are two species. To conclude, the reviewer regrets to have to express his own opinion that it would have been better if this book had never been written, at least in its present form.

Alain Olivier

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Material. Holotype @, Turkey, Hakkari, 8 km E. of Uludere, 1200 m, 10.VI.1984, H. van Oorschot leg. (HZA). Paratypes: 7@, 3#, labelled as holotype; @, #, "Achalzich Chambobel 1910 Korb" (NHMW), 2@, #, Iraq, Kurdistan, Sersang, 1500 m, I. Higgins leg. (BMNH); @, Iraq, "Shaqlawa, 2500 ft, Kurdistan, 15–24 May 1957" L. G. Higgins leg. (BMNH).

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Higgins, L. G., 1950. A descriptive catalogue of the Palaearctic *Euphydryas* (Lepidoptera: Rhopalocera). — *Trans.R.ent.Soc.Lond.* 101: 435–489, figs. 1–44, 7 maps.

Higgins, L. G. & Riley, N. D., 1980. A field guide to the butterflies of Britain and Europe. 4th ed. Collins, London. 384 p., 63 pls.

Staudinger, O., 1901. Famil. Papilionidae – Hepialidae. *In*: Staudinger, O. & Rebel, H. Catalog der Lepidopteren des palaearctischen Faunengebietes. 3. Aufl. — Friedlander & Sohn, Berlin. XXX+411 p. (Tagfalter p. 1—97).

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Revision of the south-western Palaearctic species of *Synansphecia* (Sesiidae)

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Summary. The type specimens of *Synansphecia atlantis* (Schwingenschuss, 1935), *S. borreyi* (Le Cerf, 1922), *S. powelli* (Le Cerf, 1916) and *S. aistleitneri* Špatenka, 1992 have been studied and the species are revised and redescribed in detail. The taxon *powelli* is transferred back to *Chamaesphecia*, its original combination. Two new species, *S. hispanica* sp. n. and *S. maroccana* sp. n., are described from Spain and from Morocco, respectively. A key to the Palaearctic species of the *S. triannuliformis* and *S. muscaeformis* group is presented. *S. atlantis* is known only from the High Atlas Mts in Morocco from altitudes between 2000 and 2900 m. Its host plant is supposed to be an *Armeria* species (Plumbaginaceae). It is closely related and similar to *S. borreyi* and *S. koschwitzi*. *S. borreyi* is known from different localities in Morocco from about 400 m up to 2200 m. Host plants are *Limonium* species (Plumbaginaceae). *S. hispanica* sp. n. is represented in many collections but usually has been confused with *S. atlantis*. It is widely distributed in Spain and is also found in southern France. It occurs from the coastline up to more than 2000 m in the Sierra Nevada. It is closely related to *S. maroccana* sp. n. and *S. triannuliformis* (Freyer, 1845). The host plants are various *Rumex* species (Polygonaceae). *S. maroccana* sp. n. is widely distributed in the Atlas Mts in Morocco and found at altitudes between 1600 and 2700 m. The host plant is a *Rumex* species (Polygonaceae). *Chamaesphecia powelli* comb. rev. was known for certain from the type locality in Algeria only. Recently, it has also been found in the High Atlas Mts in Morocco. It was reared from the roots of a *Nepeta* species (Lamiaceae). Additionally, *S. affinis erodiiphaga* (Dumont, 1922) is recorded from Morocco and southern Spain for the first time.

Zusammenfassung. Das Typenmaterial von *Synansphecia atlantis* (Schwingenschuss, 1935), *S. borreyi* (Le Cerf, 1922), *S. powelli* (Le Cerf, 1916) und *S. aistleitneri* Špatenka, 1992 wurde untersucht, die Arten werden revidiert und detailliert beschrieben. Das Taxon *powelli* wird der Gattung *Chamaesphecia* zugeordnet, die Orginalkombination wird damit revitalisiert. *S. hispanica* sp. n. und *S. maroccana* sp. n. werden aus Spanien bzw. aus Marokko beschrieben. Ein Bestimmungsschlüssel für die Arten der *Synansphecia triannuliformis*- und *S. muscaeformis*-Gruppe wird vorgelegt. *S. atlantis* ist aus dem Hohen Atlas in Marokko aus Höhenlagen von 2000 bis 2900 m bekannt. Vermutlich ist die Futterpflanze eine *Armeria* sp. (Plumbaginaceae). Die Art ist nahe verwandt mit *S. borreyi* und *S. koschwitzi* und ähnelt beiden Arten. *S. borreyi* ist von einer Reihe von Lokalitäten in Marokko, aus Höhenlagen von 400–2200 m, bekannt. Futterpflanzen sind verschiedene *Limonium*-Arten (Plumbaginaceae).

S. hispanica sp. n. ist in zahlreichen Sammlungen vertreten, wurde jedoch meistens mit *S. atlantis* verwechselt. Die Art ist in Spanien weit verbreitet, wird aber auch in Südfrankreich gefunden. Sie kommt von der Küste bis in eine Höhe von mehr als 2000 m in der Sierra Nevada vor. Die Art ist nahe verwandt mit *S. maroccana* sp. n. und *S. triannuliformis* (Freyer, 1845). Futterpflanzen sind verschiedene *Rumex*-Arten (Polygonaceae). *S. maroccana* sp. n. ist im Hohen und Mittleren Atlas in Marokko in Höhen zwischen 1600 m und 2700 m weit verbreitet. Sie lebt ebenfalls in einer *Rumex*-Art (Polygonaceae). *Chamaesphecia powelli* comb. rev. war bisher mit Sicherheit nur vom Typenfundort in Algerien bekannt. Inzwischen wurde sie im Hohen Atlas von Marokko aus Wurzeln einer *Nepeta* (Lamiaceae) gezogen. Außerdem wird *S. affinis erodiiphaga* (Dumont, 1922) erstmals für die Fauna Marokkos und Südspaniens nachgewiesen.

Résumé. Le matériel-type de *Synansphecia atlantis* (Schwingenschuss, 1935), *S. borreyi* (Le Cerf, 1922), *S. powelli* (Le Cerf, 1916) et *S. aistleitneri* Špatenka, 1992 a été étudié et les espèces sont révisées et redécrites en détail. Le taxon *powelli* est retransféré au genre *Chamaesphecia*, la combinaison générique originale de l'espèce. Deux nouvelles espèces, *S. hispanica* sp. n. et *S. maroccana* sp. n., sont décrites respectivement d'Espagne et du Maroc. Une clé de détermination des espèces paléarctiques des groupes de *S. triannuliformis* et de *S. muscaeformis* est presentée. *S. atlantis* n'est connue que du Haut Atlas au Maroc, entre 2000 et 2900 mètres d'altitude. Sa plante-hôte est supposée être une espèce du genre *Armeria* (Plumbaginaceae). Elle est étroitement apparentée et semblable à *S. borreyi* et à *S. koschwitzi*. *S. borreyi* est connue de différentes localités au Maroc, de 400 à 2200 m. Les plantes-hôtes sont des espèces du genre *Limonium* (Plumbaginaceae). *S. hispanica* sp. n. est représentée en de nombreuses collections, mais elle a généralement été confondue avec *S. atlantis*. Elle est largement distribuée en Espagne et se rencontre également dans le Midi de la France. Elle est trouvée de la côte jusqu'à plus de 2000 m dans la Sierra Nevada. Elle est étroitement apparentée à *S. maroccana* sp. n. et à *S. triannuliformis* (Freyer, 1845). Les plantes-hôtes sont plusieurs espèces de *Rumex* (Polygonaceae). *S. maroccana* sp. n. est largement répandue aux monts Atlas marocains, se trouvant à des altitudes de 1600 à 2700 m. La plante-hôte est une espèce de *Rumex* (Polygonaceae). *Chamaesphecia powelli* comb. rev. n'était connue avec certitude que de la localité-type en Algérie. Récemment, elle a également été trouvée dans le Haut Atlas au Maroc. Elle a été élevée à partir des racines d'une espèce de *Nepeta* (Lamiaceae). De plus, *S. affinis erodiiphaga* (Dumont, 1922) est mentionnée pour la première fois du Maroc et du sud de l'Espagne.

Key words: Lepidoptera, Sesiidae, *Synansphecia*, *hispanica* sp. n., *maroccana* sp. n., *atlantis, borreyi, Chamaesphecia powelli* comb. rev., bionomics, revision, Morocco, Spain, France, Palaearctic.

Introduction

A study of the rich material of *Synansphecia* species collected mainly by German lepidopterists in Morocco, Spain and France raised a necessity to examine a number of type specimens of

south-western Palaearctic species of *Synansphecia* Capuse, 1973. Examination of the type material of *Synansphecia atlantis* (Schwingenschuss, 1935), *S. borreyi* (Le Cerf, 1922), *S. aistleitneri* Špatenka, 1992, and *S. powelli* (Le Cerf, 1916) revealed a misinterpretation of these species. With the numerous and fresh material now available from the area and the extended knowledge of host plants there is a better basis and also the need to revise these species.

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Private collections: CDB — coll. D. Bartsch, Stuttgart; CBH — coll. D. Baumgarten, Hamburg; CEB — coll. E. Bettag, Dudenhofen; CRB — coll. R. Bläsius, Eppelheim; CTD — coll. T. Drechsel, Neubrandenburg; CJG — coll. J. Gelbrecht, Königs Wusterhausen; CTG — coll. T. Garrevoet, Antwerpen; CAK — coll. A. Kallies, Schwerin; CUK — coll. U. Koschwitz, Eppenbrunn; CAL — coll. A. Lingenhöle, Biberach; CHL — coll. H. Löbel, Sondershausen; CZL — coll. Z. Laštůvka, Brno; CMP — coll. M. Petersen, Pfungstadt; CFR — coll. F. Rämisch, Berlin; CHR — coll. H. Riefenstahl, Hamburg; CTS — coll. T. Sobczyk, Hoyerswerda; CKS — coll. K. Špatenka, Prag; CRS — coll. R. Stübinger, Hamburg.

The following abbreviations have been used throughout the text to designate particular areas of the forewing: ETA — external transparent area; ATA — anterior transparent area; PTA — posterior transparent area.

The structure of the genus *Synansphecia* Capuse, 1973

Morphological and taxonomical data of the closely related genera *Synansphecia* Capuse, 1973, *Dipchasphecia* Capuse, 1973

and *Chamaesphecia* Spuler, 1910 have been provided by Laštůvka (1990a, 1992). The genus is also closely related to the genus *Pyropteron* Newman, 1832.

The genus *Synansphecia* Capuse, 1973 is restricted to the western Palaearctic and includes 17 species at present. The larvae are root borers utilizing host plants of a wide range of plant families: Plumbaginaceae, Polygonaceae, Geraniaceae, Cistaceae, and Rosaceae. Within *Synansphecia* there are several groups of closely related species which can be separated by genitalic and external characteristics and which are restricted to specific host plant families.

a. *S. triannuliformis* group: *S. triannuliformis* (Freyer, 1845), *S. meriaeformis* (Boisduval, 1840), *S. maroccana* sp. n., *S. hispanica* sp. n.

Diagnosis. ♂ sometimes, ♀ always with white or yellow subapical spot of antenna; male genitalia very homogenous within the different species, with simple gnathos and crista sacculi (figs. 18, 19).

Host plants. Polygonaceae (*Rumex* spp.). *S. triannuliformis* has also been reported from *Geranium*, Geraniaceae (Špatenka *et al.*, 1997).

Distribution. Northwest Africa, Europe, Middle East.

b. *S. muscaeformis* group: *S. muscaeformis* (Esper, 1783), *S. borreyi* (Le Cerf, 1922), *S. atlantis* (Schwingenschuss, 1935), *S. koschwitzi* Špatenka, 1992

Diagnosis. ♂ without, ♀ usually with white to yellowish subapical spot of antenna; male genitalia very homogeneous, with simple gnathos and crista sacculi (figs. 20, 21).

Host plants. Plumbaginaceae (*Armeria* spp., *Limonium* spp.).

Distribution. Northwest Africa and south-western Europe, but *S. muscaeformis* extending to central and eastern Europe.

c. *S. leucomelaena* group: *S. leucomelaena* (Zeller, 1847), *S. aistleitneri* Špatenka, 1992, *S. kautzi* (Reisser, 1930), *S. affinis affinis* (Staudinger, 1856), *S. affinis erodiiphaga* (Dumont, 1922)

Diagnosis. ♂ without, ♀ sometimes with white to yellowish subapical spot of antenna; male genitalia with specialized gnathos (crista medialis and crista lateralis linked distally), crista sacculi hooked distally, setae often separated in two fields.

Host plants. Rosaceae (*Poterium* spp.), Cistaceae (*Helianthemum* spp., *Fumana* spp.), Geraniaceae (*Erodium* sp.). Unknown for *S. aistleitneri* and *S. kautzi.*

Distribution. Holomediterranean.

d. *S. umbrifera* group: *S. umbrifera* (Staudinger, 1870), *S. cirgisa* (Bartel, 1912), *S. koshantschikovi* (Püngeler, 1914)

Diagnosis. Rather large species; discal spot of hindwing broad, sometimes connected by scaled area to outer margin of wing; male genitalia with simple gnathos, setae of crista sacculi separated in two fields.

Host plants. Plumbaginaceae (*Limonium* spp.).

Distribution. South-eastern Europe, Middle East to western Central Asia.

e. *S. mannii* group: *S. mannii* (Lederer, 1853), *S. hera* Špatenka, 1997

Diagnosis. Small to medium sized species; ground-colour brownish; male genitalia with simple gnathos, crista sacculi strongly hooked distally, setae continuously.

Host plants. Geraniaceae (*Geranium* spp.), unknown for *S. hera*.

Distribution. Eastern Mediterranean (Bulgaria, Greece, Turkey).

Note. According to bionomic characteristics, *S. doryliformis* (Ochsenheimer, 1808) is similar to the *Synansphecia triannuliformis*-group, but isolated by genitalic and external characteristics. However, the species shows strong affinities to the genus *Pyropteron* Newman, 1832. The generic position of *S. doryliformis* and consequentely the status of the genus *Synansphecia* in relation to *Pyropteron* should be carefully investigated.

Synansphecia triannuliformis and *S. muscaeformis* species groups

The members of the *S. triannuliformis* and *S. muscaeformis* groups form a complex of closely related species. Due to their homogeneous external appearance and the lack of suitable differences in their genitalia they are often difficult to distinguish. Nevertheless, both groups are well separated by their bionomical characteristics, with larvae feeding either in species of the Polygonaceae (*S. triannuliformis* group) or Plumbaginaceae (*S. muscaeformis* group). In the adults, the two species groups can be distinguished by the presence (*S. triannuliformis* group) or absence (*S. muscaeformis* group) of a yellow to white spot of the male antenna dorso-subapically. However, this spot is usually absent in ♂♂ of *S. triannuliformis* itself, while it is present in all ♀♀ of both species groups.

The following characteristics of the male genitalia are common to both groups: valva with simple crista sacculi, curved apically, with broad scale-like setae dorsally; uncus-tegumen complex

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Figs. 1–8. 1–2 — *Synansphecia maroccana* sp. n., Morocco, Oukaimeden: 1 — ♂, paratype (CAK), wingsp. 21.5 mm. 2 — ♀, paratype (CHR), wingsp. 21.5 mm. 3–4 — *Synansphecia hispanica* sp. n., Spain: 3 — ♂, paratype (CAK), wingsp. 21.0 mm; 4 — ♀, paratype (CAK), wingsp. 21.0 mm. 5–7. *Synansphecia atlantis* (Schwingenschuss, 1935): 5 — ♂, paralectotype, Morocco (NLMW), wingsp. (reconstructed) 20.0 mm; 6 — labels of paralectotype; 7 — ♀, Morocco, Oukaimeden (BMNH), wingsp. 21.0 mm. 8 — *Synansphecia aistleitneri* Špatenka, 1992, ♀, holotype, Spain (MWM), wingsp. 22.5 mm.

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H. Atlas Maroc.
Dj. Ouchedden 2000
-2700m. 23.VI.1933
Schwingenschuss
Monogr. Pal. Ses.
Gen. No 606
Sy. atlantis
Typo
atlantis
Hmp.

6

7

8

strong, curved dorsally; crista lateralis and medialis simple, ear-shaped, not connected to each other; scopula androconialis long and strongly covered with setae; aedeagus about as long as valva, with numerous small shark tooth-shaped cornuti; saccus narrow, about half as long as aedeagus.

S. triannuliformis species group

Synansphecia triannuliformis (Freyer, 1845)

Sesia triannuliformis Freyer, 1845: 35. Type locality: Konstantinopel (Istanbul, Turkey). Type material: lost.
Bembecia triannuliformis: Heppner & Duckworth, 1981: 40.
Synansphecia triannuliformis: Laštůvka, 1990a: 94; Laštůvka, 1990b: 129–132; Špatenka *et al.*, 1993: 103; Laštůvka & Laštůvka, 1995: 96; de Freina, 1997: 166–169.

Material examined. There was no material from France available for examination. Extensive material from Germany, the Balkan Peninsula and Asia Minor has been studied.

According to Laštůvka & Laštůvka (1995), in the south-western Palaearctic this ponto-mediterranean species has only been recorded from south-eastern France, where it reaches the most western part of its range. Literature records from Spain and Morocco (de Freina, 1997) are likely to refer to *Synansphecia hispanica* sp. n., *S. maroccana* sp. n. or *S. borreyi* (Le Cerf, 1922). From these species it can easily be distinguished by the anal tuft of the male (divided into three tufts in *S. triannuliformis*, simple in the species compared), the absence of the white subapical spot of the antenna of males (present in *S. hispanica* sp. n. and *S. maroccana* sp. n.), and bionomical characteristics (the larvae of *S. borreyi* live in *Limonium* spp., those of *S. triannuliformis* in *Rumex* spp.). For details, see the key below.

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Figs. 9–16. 9–10 — *Synansphecia koschwitzi* Špatenka, 1992, Spain, Aranjuez: 9 — ♂ (CAK), wingsp. 19.0 mm; 10 — ♀ (CAK), wingsp. 19.0 mm. 11–14 — *Synansphecia borreyi* (Le Cerf, 1922): 11 — ♀, Morocco, Ifrane (CAK), wingsp. 23.5 mm; 12 — ♀, Morocco, Mrirt (CAK), wingsp. 23.5 mm; 13 — ♂, lectotype (MNHP), wingsp. 23.0 mm; 14 — labels of lectotype. 15–16 — *Chamaesphecia powelli* Le Cerf, 1916: 15 — ♀, holotype, Algeria (MNHP), wingsp. 16.0 mm; 16 — labels of holotype.

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TYPE
Maroc
Harold Powell
Chabat-el-Haouma
1er juin 1921
Ex Collection
Ch. Oberthür
par H. Biedermann
Charaeophteia
Borrayi de Cerf
Et. dépid. comp.,
XIX (1), 1922, p. 133
14

15

Charaeophteia
powelli de Cerf
Et. dépid. comp., XI,
(1), p. 15, pl. 321
fig. 4 & 4
Ex Collection
Ch. Oberthür
acquise en IV-1925
par H. Biedermann
TYPE
16

Synansphecia maroccana sp. n. (figs. 1, 2, 17a, 18)

Laštůvka & Laštůvka, 1995: 96, fig. 62; pl. 6, fig. 8 (as *S. borreyi*, misidentified); de Freina, 1997: 167, 171–172 (part.), figs. 159, 163; pl. 13, figs. 28–34 (as *S. borreyi*, misidentified), fig. 43 (as *S. atlantis*, misidentified).

Material examined. Holotype ♂, "Marokko, Haut Atlas, Oukaimeden, 2600 m, 5.–10.VII.1994 Ph[eromon] F[ang]., leg. Th. Drechsel" (MNHB). Paratypes (191♂, 3♀, all from Morocco): 74♂, same data as holotype (CAK, CMP, CKS, CHR, CEB, CJG, CFR, CTD, CZL, CTG, MNHB, ZFMK); 56♂, High Atlas, Oukaimeden, 2300–2700 m, 5.–10.VII.1994 leg. Dr. Löbel (CHL, CAK, CDB, CHR, CJG, CFR); ♂, High Atlas, Oukaimeden, 2650 m, 12.VIII.1996, leg. R. Bläsius (CRB); ♂, same data, but reared from *Rumex* sp., 9.IV.1997 e.l. (CRB); ♂, High Atlas, Oukaimeden, 2300–2700 m; 12.–15.VII.1976, leg. W. Thomas; 35♂, ♀, High Atlas, Oukaimeden, 2700 m, 22.–25.VI.1998, leg. A. Lingenhöle (CAL, CAK); ♂, High Atlas, Tizi-n-Tichka, north-side, 2000 m, 14.VI.1996, leg. A. Kallies (CAK); 9♂, ♀, Middle Atlas, Ifrane, 1700 m, 27.VI.–6.VII.1994, leg. Riefenstahl (CHR, CAK, CZL); 10♂, ♀, Ifrane, 1650 m, 28.VI.–8.VII.1994, leg. Stübinger (CAK, CRS); 2♂, Middle Atlas, Tizi n' Tretten, 30.VI.–5.VII.1994, 2200 m, leg. Riefenstahl (♂, gen. prep. by A. Kallies, prep. No. 30–96) (CAK, CHR); ♂, Daiet-Achlef, Deuxieme quinzaine de juillet, Harold Powell (CKS).

The species is present in many collections but has usually been confused with *S. borreyi* (Le Cerf, 1922). However, both species belong to different species groups.

Description (♂ holotype, paratype, fig. 1). Wingspan 21.0 mm; body length 12.5 mm; forewing length 9.5 mm; antenna 7.0 mm.

Head. Antenna black, with white spot dorso-subapically, scapus black, yellow ventrally; frons yellowish grey, yellow laterally and before antenna; labial palpus yellowish white, middle and apical joint black laterally; vertex black mixed with orange scales, without white spot between antenna and ocellus; pericephalic hairs yellow.

Thorax. Fuscous dorsally, with a narrow yellow line medially; patagia black; tegula with narrow yellow inner margin and apex; metathorax with two yellow patches submedially; fuscous ventrally, with patches of yellow scales.

Legs. Fore coxa fuscous, yellowish white apically and laterally; fore femur, tibia and tarsus fuscous, strongly mixed with yellow ventrally; mid and hind leg brownish, tibiae almost ochreous white throughout, spurs yellowish white, tarsi strongly mixed with yellow scales.

Abdomen. Blackish brown dorsally, covered with ochreous brown, partly yellow scales throughout, with a weak interrupted line medially; tergites 2, 4 and 6 each with a narrow white margin posteriorly; blackish brown ventrally, with single white scales medially; sternites 3–5 each with weak white margins posteriorly; anal tuft blackish brown dorsally, with yellow and ochreous scales medially; anal tuft ochreous yellow ventrally, blackish brown medially.

Forewing. Veins blackish brown, covered with ochreous brown scales almost throughout; ETA rounded, somewhat broader than discal spot, with a narrow extension of apical area into ETA along R_4/R_5; apical area as broad as ETA, brown, ochreous between veins; discal spot blackish brown, outer half strongly covered with light brown and yellow scales; ATA well developed; PTA weak, not reaching discal spot, partly covered with ochreous brown scales; cilia brownish grey; with brown veins ventrally, covered with yellow scales almost throughout; apical area yellow between veins.

Hindwing. Veins dark brown; discal spot very broad (fig. 17a); obtuse triangular, not reaching M_3; outer margin brownish; cilia brownish grey.

Male genitalia (fig. 18). Uncus-tegumen complex broad, strongly curved dorsally; gnathos with crista medialis relatively low, membranous extending towards proximal part; aedeagus with comparably few cornuti; saccus relatively short.

Female (paratype, fig. 2). Wingspan 21.0 mm; body length 13.0 mm; forewing length 9.5 mm; antenna 6.0 mm. Similar to ♂, but discal spot of forewing broader, that of hindwing almost reaching M_3; anal tuft with two submedial bunches of ochreous scales dorsally, somewhat darker ventrally; ATA shorter and broader; PTA present, but very narrow.

Female genitalia. Not examined.

Variation. Less variable in wingspan, size of transparent areas and coloration; wingspan from 19.0 to 22.0 mm (extreme 16.0 mm).

Differential diagnosis. This species is characterized by its ochreous brown coloration and the broad and short discal spot of the hindwing. It is closely related to *S. hispanica* sp. n., described below (see there for diagnosis). Superficially, it is also

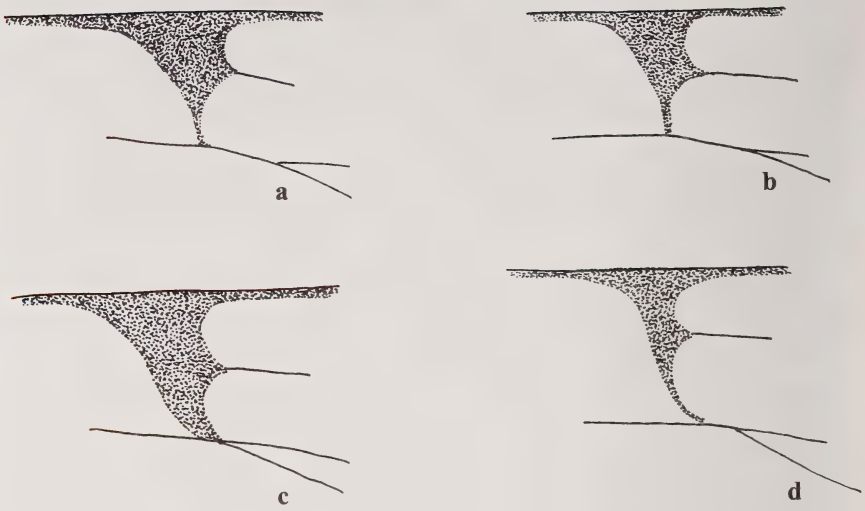


Fig. 17. Discal spots of hindwings of *Synansphecia* species: a — *S. maroccana* sp. n.; b — *S. hispanica* sp. n.; c — *S. atlantis* (Schwingenschuss, 1935); d — *S. borreyi* (Le Cerf, 1922).

similar to *S. borreyi*. From this species it can be easily distinguished by the presence of a white subapical spot of the antenna of the ♂ (not present in *S. borreyi*), by the broad and short discal spot of the hindwing (very narrow in *S. borreyi*), by the shape of the PTA (well developed in *S. borreyi*) and by the absence of the white spot between the base of antenna and the ocellus (present in *S. borreyi*).

Distribution. This species is known from the High and Middle Atlas Mts, Morocco.

Habitat and bionomics. The species was collected at altitudes between 1650 and 2700 m, adults flying from mid June to early August. The host plant is an unidentified species of *Rumex*, similar to *R. acetosa* (Drechsel & Bläsius, pers. comm.).

Synansphecia hispanica sp. n. (figs. 3, 4, 17b, 19)

Laštůvka & Laštůvka, 1995: 94, fig. 59; pl. 6, figs. 2, 3 (as *S. atlantis*, misidentified); de Freina, 1997: 166–167 (part.), 172, fig. 160, 164; pl. 13, fig. 36–42; pl. 24, fig. 6 (as *S. atlantis*, misidentified); pl. 13, fig. 51 (as *S. koschwitzi*, misidentified).

Material examined. Holotypus ♂ "5.6.1993 e.l., S[ierr]a Baza [ca. 2000 m], Prov. Almeria, Spanien, [ex] *Rumex scut*[*atus*]., leg. R. Bläsius" (MNHB). Paratypes, from Spain (95♂, 22♀): 5♂, 4♀, same data as holotype, 6.III.–10.VI.1993 e.l. (CRB, CMP); 3♂, Prov. Almeria, Sierra Baza, 1600 m, 10.VII.1993, leg. R. Bläsius (CRB); ♀, Andalusia, Sierra Baza, Escullar, 19.VI.1993, ex *Rumex scutatus*, 25.–27.VI.1993 e.l., leg. D. Bartsch (CDB); 2♂, ♀, Prov. Almeria, Sierra Filabres, Albanchez, ca. 1000 m, 1.V.–10.VI.1993 e.l., ex *Rumex scutatus*, leg. R. Bläsius (CRB, CHR); 8♂, Prov. Malaga, Jubrique, Sierra Bermeja, 500–600 m, 16.VII.1993 resp. 7.VI.1993, leg. R. Bläsius (CRB, CJG, CAK, CZL, CTS); 3♂, Prov. Almeria, Puerto Lumbreras, 25.V.1994, leg. E. Bettag (CEB); 4 Ex., Prov. Almeria, Sierra Filabres, e.l. 28.VI.1994, leg. E. Bettag (CEB); 3♂, ♀, Prov. Malaga, Ronda, 800 m, 29.V.1995 resp. 21.VII.1992 resp. 15.VII.1993, leg. R. Bläsius (CRB, CAK); 2♀, same data, but 18.IV. and 5.V.1993 e.l. leg. R. Bläsius (CHR, CZL); 4♂, Andalusia, Ronda, 500 m, 26.–27.VI.1993, leg. Bartsch (CDB); 7♂, 5♀, Andalusia, Sra de Ronda, Madronal, 600 m, 1.VII.1994, leg. Z. Laštůvka (CZL); 3♂, Andalusia, Sra de Ronda, El Burgo, 1100 m, 28.VI.1994, leg. Z. Laštůvka (CZL); 2♂, Andalusia, Sra Guillimona, 1800 m, 16.VII.1993, leg. Z. Laštůvka (CZL); ♀, Sra Nevada, N Laujar, 1600 m, 29.VI.1992, leg. Z. Laštůvka (CZL); 8♂, ♀, Prov. Malaga, Benahavis, 25.VI.1991, 200 m, leg. Riefenstahl (CHR, CMP, CKS); ♂, Prov. Malaga, Casares, 600 m, 22.VI.1991, leg. Riefenstahl (CKS); ♂, Prov. Malaga, St. Perdo, 24.VI.1991, 100 m, leg. Riefenstahl (CAK); 2♂, ♀, Andalusia, Carratraca, 300 m, 12.–13.VII.1993, leg. Z. Laštůvka (CKS, CZL); 6♂, same data, but 27.VI.1994 (CZL); 7♂, Prov. Malaga, Rio Genal, Pujerra, 30.V.1995, leg. E. Bettag (CEB); 4♂, Prov. Malaga, Ganciu, 600 m, 30.V.1995, leg. R. Bläsius (CRB); 2♂, Prov. Malaga, Juzcar, 800 m, 13.VII., 16.VII.1993 resp., leg. R. Bläsius (CRB); ♂, Prov. Granada, Sierra Blanquilla, Benaojan, 26.VI.1989, leg. K. Špatenka (CKS); 2♂, Prov. Granada, Sierra Nevada, Bayarcal, 1400 m, 15.VII.1992, leg. Bläsius (CRB); 4♂, Prov. Granada, Sierra Nevada, Trevelez, 1500 m, 20.VII.1993, leg. R. Bläsius (CRB); ♂, Prov. Murcia, Puerto Lumbreras, 600 m, 23.V.1994, leg. R. Bläsius (CRB); 10♂, Prov. Huelva, Mazagon, 0 m, 24.V.1991, leg. M. Petersen (CMP, CKS, CZL); 2♂, Prov. Cadiz, Tarifa, 0 m, 19.V.1994 bzw. 1.VI.1995, leg. R. Bläsius (CRB); ♂, Prov. Cadiz, Barbate, 0 m, 19.V.1994, leg. R. Bläsius (CRB); ♂, Prov. Leon, N Parada Secca, N Villa Franca, 6.VII.1992, leg. Fery (MNHB); ♂, Cuenca (Cast.), "an *Artemisia* fliegend", Korb 31.7.[18]96 / coll. Osthelder (ZSM); ♀, Cuenca (Cast.), "an *Salvia* fliegend", Korb 31.7.[18]96 / coll. Osthelder (ZSM). Paratypes, from France (18♂, 16♀): 7♂, 13♀, Dep. Hérault, Marseilan Plage, 26.VI.1990, leg. Baumgarten (♂, gen. prep. by A. Kallies, No. 107–96; ♂, gen. prep., *Synansphecia muscaeformis* Esp. [sic!], det. Riefenstahl) (CBH, CHR, CAK); 2♂, Gallia mer., Aigues Mortes, 19.VI.1994, leg. Z. Laštůvka (CZL); 9♂, 3♀, Camargue, vic. Aigues-Mortes, larvae 24.III.1995 ex *Rumex tingitanus*, 16.VI.–19.VII.1995 e.l., leg. D. Bartsch (CDB).

This species is represented in many collections, but usually confused with *S. atlantis* (Schwingenschuss, 1935). However, both species belong to different species groups. *S. atlantis* is known only from the High Atlas Mts, Morocco, while *S. hispanica* sp. n. is restricted to south-western Europe.

Description (♂ holotype, paratype, fig. 3). Wingspan 19.0 mm; body length 13.0 mm; forewing length 9.0 mm; antenna 6.5 mm.

Head. Antenna black, with prominent white spot dorso-subapically, scapus black, grey ventrally; frons leaden grey, white laterally; labial palpus white, middle and apical joint mixed with black scales laterally and dorsally; vertex black, with some yellow scales anteriorly; a small white spot between antenna and ocellus present; pericephalic hairs yellow dorsally, white ventrally and laterally.

Thorax. Black dorsally, with a weak yellow line medially; patagia black; tegula with narrow yellow inner margin; metathorax yellowish white, black ventrally, with patches of pale yellow and white scales.

Legs. Fore coxa white, blackish grey interiorly; fore femur, tibia and tarsus blackish grey; mid and hind leg blackish, mid femur with anterior margins pale yellowish white; mid tibia white dorsally, spurs grey; proximal two thirds of hind tibia white dorso-laterally, spurs white.

Abdomen. Fuscous; tergites partly with brown scales anteriorly; tergite 1 with some yellowish white scales posteriorly; tergites 2, 4 and 6 with narrow white margins posteriorly; sternites fuscous with a few white scales on sternites 3 and 4; abdomen with an almost complete narrow white line laterally; anal tuft fuscous dorsally, with single yellow scales medially, with some submedial yellow scales ventrally.

Forewing. Black; ETA rounded, as broad as discal spot, consisting of a small cell between R_3 and R_4/R_5, three long cells between R_4/R_5 and M_3 and a small cell between M_3 and Cu_1 (the small cells more or less covered with whitish hyaline scales); discal spot black, with a few ochreous scales externally; apical area blackish, light grey between veins; ATA well developed; PTA developed, not extending to discal spot; cilia black; veins black ventrally, but discal spot and apical area strongly dusted with white scales; apical area black, with white scales between veins.

Hindwing. Veins black; discal spot (fig. 17b) broad triangular, extending to half distance between M_2 and M_3; outer margin black; cilia black; veins black ventrally, dusted with white scales.

Male genitalia (fig. 19). Similar to *S. maroccana.* Uncus-tegumen complex narrower, less strongly curved; gnathos with

crista medialis relatively high and more strongly curved, not extending towards proximal part; aedeagus with many small cornuti; saccus slightly longer.

Female (paratype, fig. 4). Wingspan 20.0 mm; body length 13.0 mm; forewing length 9.0 mm; antenna 6.0 mm.

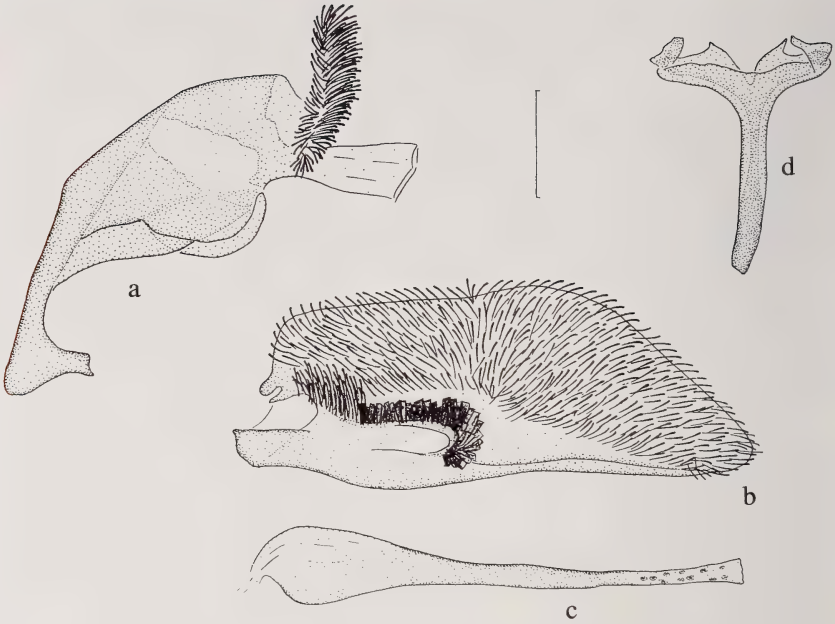
Females differ from males by the following characteristics: PTA weak, covered with black scales almost throughout; ATA bordered with yellow scales; veins in ETA covered with yellow scales; costal margin yellow subapically; abdomen with well-developed yellow line medially (more or less disrupted in spots); yellow posterior margins of tergites broader; anal tuft with two white submedial tufts dorsally.

Variation. Wingspan from 18.0 to 21.0 mm in ♂♂ (exceptionally 14.0 mm), 18.0 to 23.0 mm in ♀♀. This species is somewhat variable in the size of the ETA, usually consisting of 5 cells, in ♀♀ frequently only of 3 to 4 cells. The medial dorsal line of the abdomen is often weakly expressed. Specimens from France are usually somewhat larger than those from Spain.

Differential diagnosis. *S. hispanica* is closely related to *S. maroccana*, but differs by the black coloration and the white pattern of the body and legs (ochreous brown with yellowish pattern in *S. maroccana*), by the small discal spot of the hindwing (broad in *S. maroccana*), and by the presence of a small snow-white spot between base of antenna and ocellus (absent in *S. maroccana*). There are additional differences in the discal spot of the forewing in the ♀♀ (broader in *S. maroccana*), in the ATA (shorter in *S. maroccana*), and the PTA (well developed in *S. maroccana*).

Distribution. This species is known from Andalusia (Malaga, Almeria, Granada, Murcia, Cadiz, Huelva) and Castilia (Cuenca, Leon) to the Mediterranean coast in southern France.

Habitat and bionomics. In Spain this species is found at altitudes from sea level up to more than 2000 m in the Sierra Nevada, adults being observed from the middle of May to the end of July. In France the species was found only at sea level close to the coast in June. In Spain, *Rumex scutatus* was recorded as the larval host plant by R. Bläsius. In southern France *S. hispanica* lives in *Rumex tingitanus* (D. Baumgarten & D. Bartsch, pers. comm.). Males are attracted by artificial phero-



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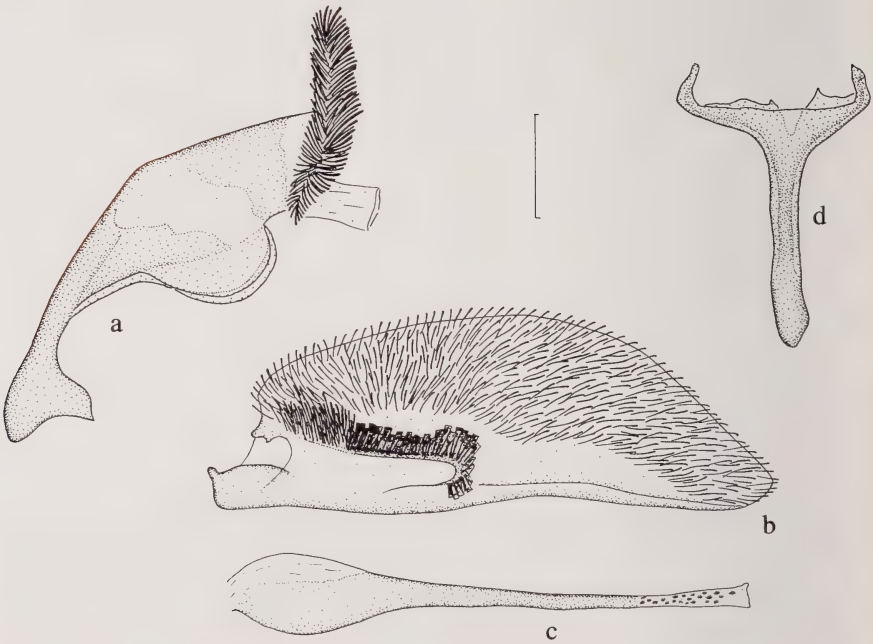

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mones in the afternoon between 2:00 and 5:30 p.m. (Riefenstahl, pers. comm.). According to the attached labels two specimens collected by Korb were observed visiting *Artemisia* and *Salvia*.

Synansphecia meriaeformis (Boisduval, 1840)

Sesia meriaeformis Boisduval, 1840: 42. Type locality: Andalusia (Granada), Spain. Type material: lost.
Chamaesphecia meriaeformis: Heppner & Duckworth, 1981: 35.
Synansphecia meriaeformis: Laštůvka, 1990a: 94; Špatenka *et al.*, 1993: 103; Laštůvka & Laštůvka, 1995: 92; de Freina, 1997: 176–178.

Material examined. Numerous specimens from France and Italy were studied. The species is present in most of the collections mentioned above.

A well-known species occurring in southern France, Spain, and Italy. It is the smallest species of the genus and it can usually be distinguished easily from all congenerics (see the key below).

S. muscaeformis species group

Synansphecia muscaeformis (Esper, 1783)

Sphinx muscaeformis Esper, 1783: 217. Type locality: Frankfurt/Main (Germany). Type material: lost.
Bembecia muscaeformis: Heppner & Duckworth, 1981: 39.
Synansphecia muscaeformis: Laštůvka, 1989: 177–180; Laštůvka, 1990a: 94; Špatenka *et al.*, 1993: 103; Laštůvka & Laštůvka, 1995: 98; de Freina, 1997: 169–171.

Material examined. 2♂, 2♀, [France] Sene, 31. Mai–6. Juin / J. de Joannis O2 dom. (lectotype and paralectotypes of *Sesia philanthiformis* ssp. *occidentalis* de Joannis, 1908; designated by Špatenka, 1992a); ♂, Spain, Prov. Lerida, Coll. del Canto, 1600 m, 19.VII.1993, leg. et coll. Laštůvka. Additional extensive material from Germany, Austria, and Italy has been examined.

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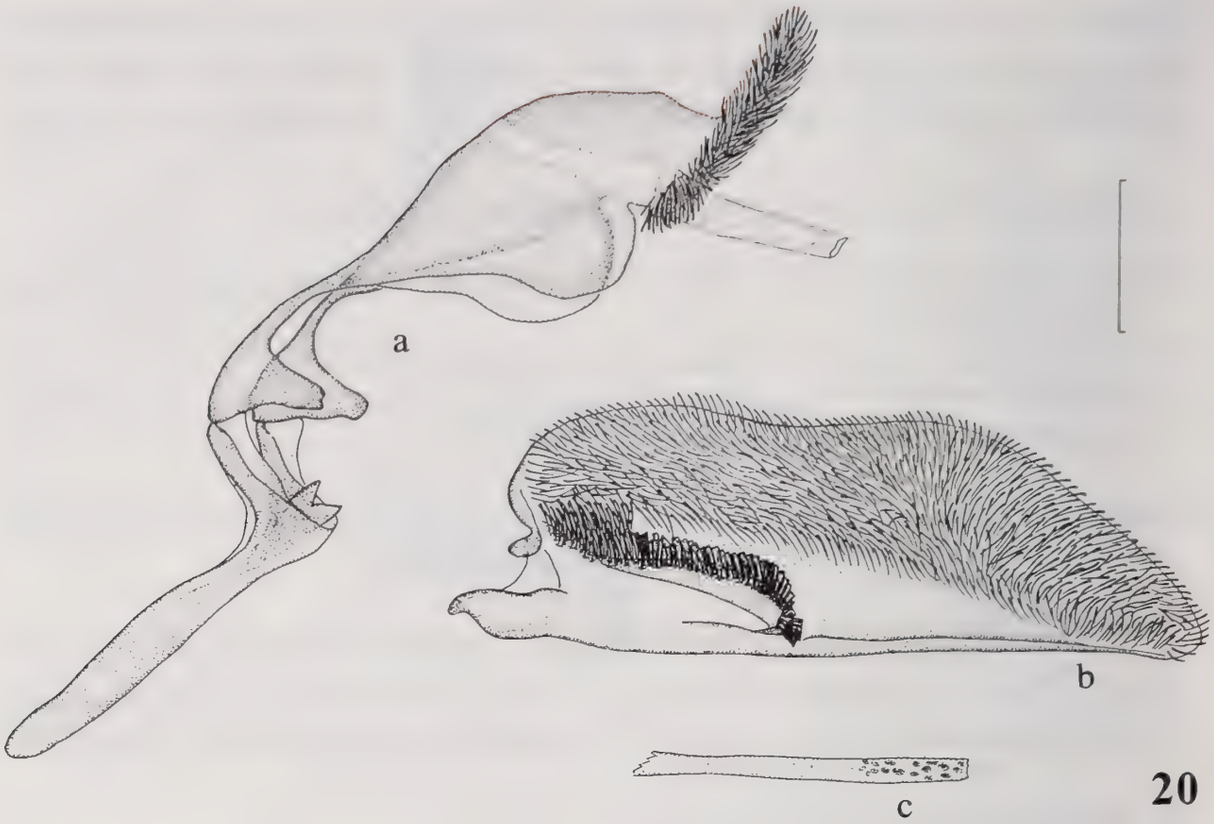
Fig. 18. *Synansphecia maroccana* sp. n., paratype ♂, Morocco, Oukaimeden, genitalia (gen. prep. AK27) (CAK): a — tegumen-uncus complex; b — valva; c — aedeagus; d — vinculum, saccus. Reference bar 0.5 mm.
Fig. 19. *Synansphecia hispanica* sp. n., paratype ♂, Spain, Malaga, genitalia (gen. prep. AK97) (CAK): a — tegumen-uncus complex; b — valva; c — aedeagus; d — vinculum, saccus. Reference bar 0.5 mm.



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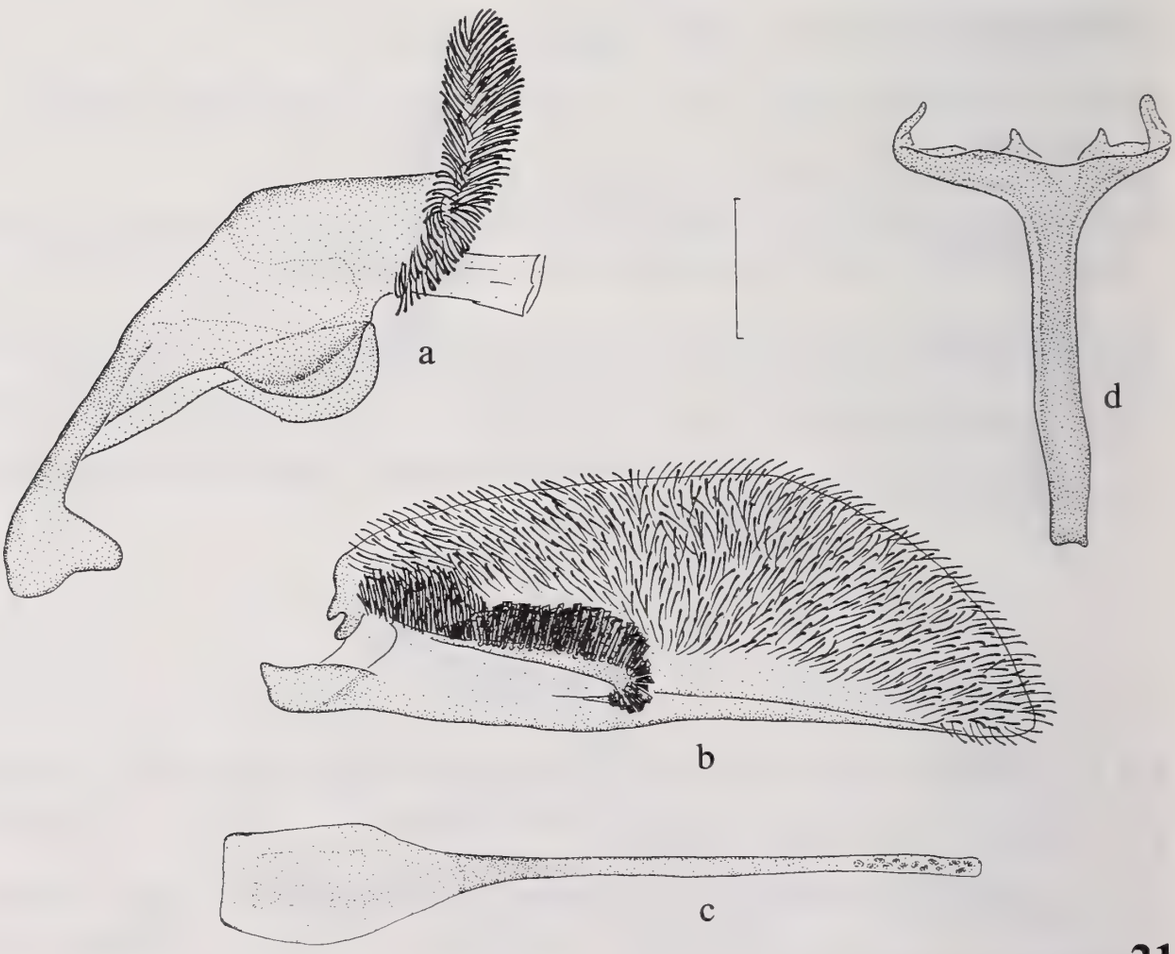

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According to Laštůvka & Laštůvka (1995), in addition to the main part of its range in central Europe this species occurs in northern and western France, and in the Pyrenees.

The only specimen from Spain, which was available for examination was collected in a population of *Armeria* (Laštůvka, pers. comm.).

Synansphecia borreyi (Le Cerf, 1922) (figs. 11, 12, 13, 14, 17d, 21, 22)

Chamaesphecia borreyi Le Cerf, 1922: 133. Type locality: Morocco, Chabat-el-Hamma. Lectotype: ♂ (MNHP, designated by Špatenka, 1992a). Heppner & Duckworth, 1981: 35.

Synansphecia borreyi: Špatenka, 1992a: 490; Špatenka *et al.*, 1993: 102; Laštůvka & Laštůvka, 1995: 96 (part.); de Freina, 1997: 171–172 (part.).

Material examined. Lectotype ♂, with labels illustrated on Fig. 14; Paralectotypes: 2♂, 3♀ with identic labels (♂ gen. prep. AK26, ♀ gen. prep. AK50) (MNHP). Additional material from Morocco: ♀, same data as holotype, without type label (CTG); 9♂, 8♀, Middle Atlas, Tizi n' Tretten, 1900 m, 10 km south of Ifrane, larva: 16.IV.1997, reared from *Limonium* sp., 10.–15.VI.1997 e.l., leg. A. Kallies (CAK); 4♂, 4♀, Middle Atlas, 5km NNE Mrirt, ca. 1200 m, larva: 14.IV., reared from *Limonium* sp., 15.–31.V.1997 e.l., leg. A. Kallies (CAK); 35♂, 4♀, Middle Atlas, Ifrane, 1700 m, 27.VI.–6.VII.1994, leg. Riefenstahl (CHR, CAK, CEB, CKS, CZL, CAL); 20♂, 2♀, same data, but leg. Stübinger (CRS, CHR, CAK); 5♂, ♀, Middle Atlas, Tizi n' Tretten, 30.VI.–5.VII.1994, 2200 m, leg. Riefenstahl (CHR).

This species was described from a series of specimens taken in western Morocco. Later, it has usually been confused with *S. maroccana* sp. n. (Laštůvka & Laštůvka, 1995; de Freina, 1997), described above. According to the bionomical data and the external characteristics both species belong to different species groups.

←

Fig. 20. *Synansphecia atlantis* (Schwingenschuss, 1935), paralectotype ♂, Morocco, Dj. Oucheddene, genitalia (gen. prep. AK86) (NLMW): a — tegumen-uncus complex; b — valva; c — aedeagus. Reference bar 0.5 mm.

Fig. 21. *Synansphecia borreyi* (Le Cerf, 1922), paralectotype ♂, Morocco, Chabat-el-Hamma, genitalia (gen. prep. AK21) (MNHP): a — tegumen-uncus complex; b — valva; c — aedeagus; d — vinculum, saccus. Reference bar 0.5 mm.

Fig. 22. *Synansphecia borreyi* (Le Cerf, 1922), paralectotype ♀, Morocco, Chabat-el-Hamma, genitalia (gen. prep. AK50) (MNHP). Reference bar 0.5 mm.

Description (♂ lectotype, fig. 13). Wingspan 23.0 mm; body length 13.5 mm; forewing length 10.5 mm; antenna 7.5 mm.

Head. Antenna black, without white spot subapically; frons leaden grey, white laterally; vertex black with orange-yellow scales anteriorly; labial palpus white, middle joint with narrow black stripe laterally, apical joint mixed with black; a white spot between base of antenna and ocellus.

Thorax. Black, with a narrow yellow line medially; patagia black, white ventro-laterally; tegula black, with narrow yellow inner margin and yellow scales apically; mesothorax with two white patches submedially; thorax fuscous ventrally, with small patches of white to pale yellow scales laterally.

Legs. Fore coxa snow-white (other parts missing); mid femur fuscous, with white hair-like scales and with yellowish white anterior margin, white interiorly; base of mid tibia brownish grey externally, ochreous distally, white interiorly; spurs white; mid tarsus grey, mixed with white scales (hind leg broken off) Paralectotype: hind femur fuscous with white hair-like scales, anterior margin yellowish white; hind tibia white ochreous, exteriorly fuscous subapically, base interiorly fuscous; spurs white; hind tarsus fuscous, dusted with white scales.

Abdomen. Black, covered with beige brown scales almost throughout; tergites 2–7 with white line medially; tergite 1 scattered with a few yellow-white scales; tergite 2 with white scales at posterior margin laterally; tergite 4 with narrow white margin posteriorly; sternites black, each with a narrow white posterior margin, dusted with white scales throughout; anal tuft black dorsally, with tufts of white scales medially and laterally; anal tuft white almost throughout ventrally.

Forewing. ETA broader than high, about 1.8 as broad as discal spot, consisting of 5 cells, with a small projection of apical area into ETA between R_4/R_5; apical area fuscous with yellowish ochreous scales between veins, near M_1 narrower than ETA; ATA and PTA well developed; PTA almost reaching discal spot of forewing; discal spot fuscous, with brownish ochreous scales exteriorly; veins fuscous, dusted with yellow to ochreous scales; cilia fuscous; similar ventrally, but veins strongly dusted with white scales.

Hindwing. Discal spot narrow, triangular, extending to half way between M_2 and M_3/Cu_1; veins and cilia fuscous; similar ventrally, but veins heavily dusted with white scales.

Male genitalia (fig. 21). Uncus-tegumen complex relatively narrow; gnathos with crista medialis of medium hight, somewhat membranous towards proximal part; aedeagus with small cornuti; saccus long and narrow.

Female (figs. 11, 12). Similar to male, but differing by the smaller ETA (rounded, about 1.3 as broad as discal spot); apical area broader, almost as broad as ETA at vein M_1; the white to yellow mediodorsal abdominal line more strongly expressed; antenna with few white scales subapically.

Female genitalia (fig. 22). Papilla analis membranous, slightly sclerotized ventrally, covered with long setae; posterior apophysis longer than anterior apophysis; antrum well sclerotized, less so in medial part; bursa rounded, membranous, with only very weak sclerotization near ductus bursae.

Variation. A rather variable species, both in size and coloration even within populations. Wingspan of ♂♂ 18–23 mm, ♀♀ 19–24 mm; the yellow mediodorsal line on thorax and abdomen may be absent; the ochreous to brown scales vary in abundance; the extension of the ETA varies (1.8 to 2.5 as broad as discal spot in ♂♂, 1 to 1.5 in ♀♀), fore coxa sometimes with grey scales interiorly in ♂♂.

Diagnosis. *S. borreyi* is closely related and similar to *S. koschwitzi* and *S. atlantis*. Both differ from *S. borreyi* in the ETA (small and rounded in the species compared); the apical area (broader); the coloration of body and wings (without ochreous brown scales); in the PTA (shorter); the discal spot of the hindwing (broader) and by the fore coxa in the ♂ (always black interiorly). See also key below.

Distribution. This species is known from the type locality near Rabat in western Morocco and from the Middle Atlas Mts in central Morocco. Literature records from Spain (Laštůvka & Laštůvka, 1995) refer to *Synansphecia hispanica* sp. n. described above.

Habitat and bionomics. Specimens were bred from roots of two different *Limonium* species from the Middle Atlas near Mrirt (Petersen & Lingenhöle, pers. comm.; Kallies, pers. obs., 1997)

and Ifrane (Kallies, pers. obs., 1997), respectively. The species is known from altitudes between 400 and 2200 m. Adults have been collected between 1st and 29th of June. Most likely the flight period starts in mid May at lower altitudes. In the cold spring of 1997 fully grown larvae and pupae were found in April.

Synansphecia koschwitzi Špatenka, 1992 (figs. 9, 10)

Synansphecia koschwitzi Špatenka, 1992b: 437. Type locality: Central Spain, Prov. Toledo, Aranjuez. Type material: holotype, ♂ (MWM). Laštůvka & Laštůvka, 1995: 98, fig. 63; pl. 6, fig. 7; de Freina, 1997: 175–176, figs. 165, 167; pl. 13, figs. 47–50.

Material examined. Numerous specimens from the type locality (CKS, CUK, CAK, CHR).

This species was described after a series of ♂♂ taken near Aranjuez, central Spain (Špatenka, 1992b). Later, it was reared from larvae boring in roots of a *Limonium* sp., which was identified as *L. toletanum* (Koschwitz, pers. comm., Špatenka *et al.*, 1996).

The female (fig. 10) had not yet been described or figured. It differs from the ♂ by the white subapical spot in the antenna, the smaller ETA (consisting of 5 cells, anterior and posterior cell usually covered with pale yellow to white scales), the weak PTA, the entirely white coxa of the fore leg, and the anal tuft (mixed with white dorsally).

Note. It can not be excluded that *S. koschwitzi* represents only an isolated subspecies of *S. borreyi*. However, both taxa can easily be distinguished by the shape of the ETA and the discal spot (cf. diagnosis for *S. borreyi*). It would be most interesting to study populations of *Synansphecia* spp. from southern Spain and northern Morocco living in *Limonium*. A record of *S. koschwitzi* from Malaga (de Freina, 1997) refers to *S. hispanica* sp. n., described above.

Synansphecia atlantis (Schwingenschuss, 1935) (figs. 5, 6, 7, 17c, 20)

Chamaesphecia atlantis Schwingenschuss, 1935: 106. Type locality: Morocco, High Atlas, Dj. Oucheddene, 2200 m. Type material: lectotype, ♂ (NLMW, designated by Špatenka, 1992a). Heppner & Duckworth, 1981: 35.

Synansphecia atlantis: Špatenka, 1992a, 499; Špatenka *et al.*, 1993: 102; Laštůvka & Laštůvka, 1995: 94 (part.); de Freina, 1997: 172–173 (part.).

Material examined. Paralectotype ♂ (fig. 5), with labels illustrated on fig. 6 (NLMW). Additional material from Morocco: 9♂, High Atlas, Tizi-n-Tichka, north-side, 2000 m, 14.VI.1996, leg. A. Kallies, M. Petersen & U. Koschwitz (CAK, CMP, CUK); ♂, High Atlas, Oukaimeden, 2800 m, 8.VII.1975, leg. E. Reichl (CAK); ♂, High Atlas, Oukaimeden, 2500 m, 17.VI.1994, leg C. Kassebeer (CHR); ♀, High Atlas, Oukaimeden, 2600–2700 m, 24.–30.VII.1985, W. G. Tremewan (BMNH); ♀, High Atlas, Djebel Oukaimeden, 2650–2900 m, 24.–28.VII.1985, W. G. Tremewan (BMNH); ♀, High Atlas, Djebel Oukaimeden, 2700–2850 m, 20.VII.1979, leg. H. Hepp (CHR); 38♂, 2♀, High Atlas, Oukaimeden, 2700 m, 22.VI.1998, leg. A. Lingenhöle (CAL, CAK).

This species was described after two male specimens collected in the High Atlas (Djebel Oucheddene, south of Ijoukak) at an altitude of 2200 m. Both specimens were examined by Špatenka (1992a). Later, specimens of a related species of *Synansphecia* were discovered in Spain and France. They were usually referred to *S. atlantis*. However, detailed examination of the paralectotype of *S. atlantis* revealed striking differences between the Moroccan and south-western European populations of these *Synansphecia* species, both belonging to different species groups. Therefore, it appeared necessary to redescribe *Synansphecia atlantis* and to describe the European populations as a new species, *S. hispanica* sp. n.

Description (♂ paralectotype, fig. 5). Wingspan (reconstructed) 20.0 mm; forewing length 9.0 mm; antenna 6.5 mm.

Head. Antenna black throughout; frons white mixed with leaden grey scales, scapus with white scales ventrally; labial palpus white, strongly tufted with black scales ventro-laterally, apical joint black laterally; vertex black; pericephalic hairs orange dorsally, white ventrally and laterally.

Thorax (somewhat descaled). Black dorsally; patagia black, white ventro-laterally; tegula with narrow white inner margin and white scales apically; black ventrally, with a patch of white scales below forewing.

Legs. Black; outer margin of fore coxa with a white stripe; fore tibia with white hairs dorsally; mid tibia with white tufted hairs dorsally; basal two-thirds of hind tibia with white tufted hairs; spurs black ventrally, whitish dorsally.

Abdomen. Fuscous; tergite 2 with narrow white margin posteriorly and white scales laterally (remaining parts missing).

Forewing. ETA rounded, consisting of 5 cells, only slightly broader than discal spot; posterior and anterior cell small, with single white scales at cross vein; ATA short, scaled near base; PTA short, extending to discal spot of hindwing only; apical area as broad as ETA, black with white scales between veins; veins dusted with white scales ventrally.

Hindwing. Veins black; discal spot (fig. 17c) black, triangular, extending to M_3.

Male genitalia (fig. 20). Similar to *S. borreyi.* Gnathos with crista medialis raised and strongly curved, somewhat exceeding crista lateralis proximally.

To complete a description of the male the following abdominal characteristics observed in recently collected specimens from the High Atlas are added: abdomen fuscous, with undefined white mediodorsal line, fuscous with scattered white scales ventrally, with narrow white line laterally. Tergites 2, 4 and 6 with narrow white posterior margins; sternites 3–7 with white scales at posterior margin; anal tuft fuscous, with groups of white scales laterally and ventrally.

Female (fig. 7). Wingspan 23.0 mm; body length 12.0 mm; forewing length 10.0 mm; antenna 7.0 mm. Similar to male, but differing by a small patch of white scales on the antenna dorso-subapically; inner margin of tegula yellow; metathorax with two small patches of white scales submedially; tergites with white scales medially, forming an undefined interrupted mediodorsal line; anal tuft with two tufts of white scales submedially; fore coxa white almost throughout; thorax with large yellowish white patch of scales laterally.

Variation. Only a single ♂ (paralectotype) of the original type series could be located and examined. According to Špatenka (in litt.) and to the original description both type specimens were found to be identic. Some of the subsequently collected specimens differ by the shape of the ETA (somewhat broader) and by the extension of the discal spot of the hindwing (not reaching M_3/Cu_1). In one ♀ the posterior as well as the anterior cell of the ETA is covered with scales throughout, the PTA is extremely short. Wingspan in ♂♂ ranging from 16.0–22.0 mm, in ♀♀ from 18.5–23.0 mm.

Diagnosis. This species is probably closely related to *S. muscaeformis*, but more similar to *S. koschwitzi* and *S. borreyi* (see there for diagnosis). *S. muscaeformis* can be distinguished by the discal spot of the hindwing (narrow, pointed, reaching M_3/Cu_1) and by the coloration of body and wings (with yellow scales especially in labial palpus, frons, abdomen and along margins of transparent areas).

Distribution. *Synansphecia atlantis* probably occurs over the entire range of the High Atlas. In addition to the type locality, specimens from the Tizi-n-Tichka and from Oukaimeden are known.

Habitat and bionomics. The type specimens were collected at about 2200 m at the end of June (Schwingenschuss, 1935). In mid-June 1996, M. Petersen, U. Koschwitz and the author collected a small series of specimens near the Tizi-n-Tichka in the High Atlas, at an altitude of about 2000 m. These specimens were attracted to artificial pheromones in the afternoon. The habitat was a high mountain meadow densely covered with a white flowering *Armeria* species (*A. allioides*?), common in the High Atlas. In the roots of this *Armeria* a fully grown larva was found, which unfortunately died. It is assumed that the specimens collected at that place developed in *Armeria*. Specimens were observed in similar habitats near Oukaimeden (Lingenhöle, pers. comm.). Here *S. atlantis* has been collected in *Armeria* populations at altitudes between 2500 and 2900 m from the middle of June to the end of July.

Key to the south-western Palaearctic species of the *Synansphecia muscaeformis* and *S. triannuliformis* group

1. Antenna yellow to ochreous ventrally; abdomen brown in ♂, more or less covered with yellow scales; tegula with red inner margin in ♀; legs mainly yellow ..... *S. doryliformis*
—. Antenna black, sometimes with white subapical spot in ♂, usually so in ♀; tegula with white or yellow inner margin 2
2. Anal tuft divided into 3 tufts in ♂; antenna usually without white subapical spot in ♂; PTA well developed in ♀ (Asia Minor, south eastern and central Europe to south-eastern France, host plants *Rumex* spp.) ..... *S. triannuliformis*
—. Anal tuft simple, antenna with or without whitish subapical spot in ♂; PTA developed or covered with scales in ♀ 3

3. Antenna usually with white subapical spot in both sexes (host plants *Rumex* spp., Polygonaceae) 4
—. Antenna without white subapical spot in ♂, in ♀ typically present, rarely absent; (host plants *Armeria* spp., *Limonium* spp., Plumbaginaceae) ... 6
4. Wingspan usually 14–16 mm; subapical spot of antenna undefined in ♂; PTA in both sexes covered with scales almost throughout; ETA small, usually consisting of three cells (Italy, southern France, Iberian Peninsula) ..... *S. meriaeformis*
—. Wingspan usually 18–23 mm; subapical spot of antenna well defined in ♂; PTA well developed in ♂; ETA broader, usually consisting of five cells 5
5. Coloration of abdomen and veins mainly black, vertex black, a small white spot between base of antenna and ocellus; PTA covered with scales almost throughout in ♀ (Spain and southern France) ..... *S. hispanica* sp. n.
—. Coloration of abdomen and veins mainly ochreous brown, vertex mixed with orange scales, without white spot between antenna base and ocellus; PTA small in ♀ (Morocco, Atlas Mts) ..... *S. maroccana* sp. n.
6. Ground colour yellowish brown, labial palpus, frons and margins of transparent areas of forewing with yellow scales (host plants *Armeria* spp.) ..... *S. muscaeformis*
—. Ground colour blackish grey, labial palpus, frons and margins of transparent areas of forewing with white or pale yellow scales 7
7. ETA usually twice as broad as discal spot, PTA almost reaching discal spot, discal spot of hindwing narrow, pointed; transparent areas well developed in ♀ (Morocco; host plants *Limonium* spp.) ..... *S. borreyi*
—. ETA as broad as discal spot or slightly broader, discal spot of hindwing broad and not pointed, transparent areas very small in ♀ 8
8. PTA short, usually extending to discal spot of hindwing only (Morocco, High Atlas; host plant *Armeria* sp.) ..... *S. atlantis*
—. PTA very short, usually not extending to discal spot of hindwing (Spain; host plant *Limonium* sp.) ..... *S. koschwitzi*

S. leucomelaena species group

Synansphecia leucomelaena (Zeller, 1847)

Sesia leucomelaena Zeller, 1847: 410. Type locality: Turkey, Macri (now Fethiye). Type material: lectotype ♂ (BMNH, Špatenka design., 1992a).
Chamaesphecia leucomelaena: Le Cerf, 1916: 497; Heppner & Duckworth, 1981: 36.
Synansphecia leucomelaena: Laštůvka, 1990a: 94; Špatenka, 1992a: 496; Špatenka *et al.*, 1993: 103; Laštůvka & Laštůvka, 1995: 100; de Freina, 1997: 180–182.

Material examined. Numerous specimens from southern France, southern Spain and Portugal (CFR, CAK, CJG, MWM). In addition, extensive material from Turkey and Greece has been studied.

According to Laštůvka & Laštůvka (1995), in the south-western Palaearctis this species is known from southern France, the Iberian Peninsula and Northwest Africa. Records from southern Spain and Northwest Africa should be carefully examined to exclude confusion with *S. aistleitneri.*

Synansphecia aistleitneri Špatenka, 1992 (fig. 8)

Synansphecia aistleitneri Špatenka, 1992b. Type locality: Spain, Andalusia, Prov. Granada, Sierra de Guillimona. Type material: holotype ♀ (MWM). Špatenka *et al.*, 1993: 102; Laštůvka & Laštůvka, 1995: 94, fig. 60; pl. 6, fig. 1; de Freina, 1997: 173, fig. 166; pl. 13, figs. 44–45.

Material examined. Holotypus ♀, "Hispania, Prov. Granada sept., Sra. Guillimona, 1900 m, 15. 7. 88, leg. Aistleitner, coll. Nr. 88/09a" / "*Synansphecia aistleitneri* sp. n., Holotypus ♀, K. Špatenka des. 1989".

This species was described after two specimens originating from the Sierra de Guillimona, the ♀ holotype (fig. 8) and a ♂ paratype (Špatenka, 1992b). The genitalia of the ♂ clearly prove that it forms part of the *leucomelaena* species group. However, it can not be excluded that the male paratype represents a species different from the holotype. In the past, the holotype ♀ was placed close to *S. hispanica* sp. n. (misidentified as *S. atlantis*) and the identity of both taxa has been proposed (Laštůvka & Laštůvka, 1995). Comparison of the holotype of *S. aistleitneri* with numerous female specimens of *S. hispanica* and *S. atlantis* has shown that this species is in fact different from both species. *S. aistleitneri* is associated here with the *S. leucomelaena* species group.

Differential diagnosis. Differences between the holotype ♀ of *S. aistleitneri* and ♀♀ of *S. hispanica* sp. n. (misidentified as *S. atlantis*) have been discussed by Laštůvka & Laštůvka (1995). The following points should be added: ATA in *S. aistleitneri* fairly short and broad (longer and narrower in *S. hispanica.*); PTA short in *S. aistleitneri*, but well developed (extremely narrow and covered with scales almost throughout in *hispanica*); costal margin of forewing black subapically (white in *S. hispanica*); abdomen black ventrally (brownish black in *S. hispanica*); without white line laterally (white line present in *S. hispanica*).

Distribution. Known from the type locality in southern Spain only. Male specimens resembling the paratype of *S. aistleitneri*

were also collected in different localities in the High and Middle Atlas by Petersen & Kallies in 1996, but their identity has not yet been established.

Habitat and bionomics. The type series (♂, ♀) was collected in a rocky site at 1900 m in the Sierra de Guillimona in the middle of July. Specimens from Morocco which might belong to *S. aistleitneri* were collected at altitudes between 1700 and 2200 m in June.

Note. Without the knowledge of the host plant and analysis of clearly conspecific males the exact systematic position of *S. aistleitneri* within the genus *Synansphecia* cannot be established.

Synansphecia kautzi (Reisser, 1930)

Chamaesphecia kautzi Reisser, 1930: 104. Type locality: Spain, Sierra Nevada, Monte del Lobo. Type material: lectotype ♀ (MNK, designated by Špatenka, 1992a, destroyed)

Chamaesphecia kautzi: Heppner & Duckworth, 1981: 36.

Synansphecia kautzi: Laštůvka, 1990a: 94; Špatenka, 1992a: 499; Špatenka *et al.*, 1993: 103; Laštůvka & Laštůvka, 1995: 106; de Freina, 1997: 191.

This species was previously known only after 5 female type specimens from the Sierra Nevada, Spain. Three of these, including the lectotype, were destroyed. The remaining two paralectotypes are deposited in the MNK and NHMW, respectively.

Recently a male of this species was captured near the type locality. This specimen shows strong similarities with the species of the *S. leucomelaena* group by external appearance and characteristics of the genitalia (Pühringer & Pöll, 1999). However, since the bionomics of *S. kautzi* (Reisser, 1930) are unknown, this species cannot be assigned with certainty to a species group at present.

Synansphecia affinis affinis (Staudinger, 1856)

Sesia affinis Staudinger, 1856: 278. Type locality: Bolzano (Italy). Type material: lectotype ♀ (MNHB, designated by Špatenka & Laštůvka, 1988).

Chamaesphecia affinis: Heppner & Duckworth, 1981: 34.

Synansphecia affinis: Laštůvka, 1990a: 94; Špatenka *et al.*, 1993: 102; Laštůvka & Laštůvka, 1995: 100; de Freina, 1997: 178–180.

Material examined. Extensive material from Germany, Hungary, Greece and Turkey has been investigated.

According to Laštůvka & Laštůvka (1995), in the south-western Palaearctic this species is known from southern and south-western France and from the Iberian Peninsula.

Synansphecia affinis erodiiphaga (Dumont, 1922)

Chamaesphecia erodiiphaga Dumont, 1922: 215. Type locality: Tunis (Tunisia). Type material: lectotype ♀ (NHMP, designated by Špatenka, 1992a). Heppner & Duckworth, 1981: 36.

Synansphecia affinis ssp. erodiiphaga: Špatenka, 1992a: 491; Špatenka *et al.*, 1993: 102; de Freina, 1997: 180.

Material examined. ♂, Morocco, Middle Atlas, Mischliffen crater, 1950 m, 1.VI.1984 / W. G. Tremewan, BM 1984–236 / gen. prep. by A. Kallies, gen. prep. AK87 (BMNH); ♂, Spain, Malaga, 8.VI.1994, leg. H. Riefenstahl (CHR).

So far, this subspecies had only been recorded from Tunisia. Recently, two ♂♂ from Morocco and Spain were collected. They differ from typical *S. affinis affinis* by the large ETA (consisting of 5 cells) and the wider wingspan (19–20 mm). These specimens are referred to *S. affinis erodiiphaga* here though this identification remains provisional since the larval hosts of the southern Spanish and Moroccan populations are not known.

Note. Larvae of *S. affinis erodiiphaga* were found in the roots of *Erodium arborescens* (Geraniaceae), whereas the larvae of *S. affinis affinis* live in Cistaceae species. Records of larvae from *Erodium* spp. are known only from Tunisia. The status and distribution of the subsp. *erodiiphaga* requires further attention because it may represent a species distinct from *S. affinis*.

Excluded from *Synansphecia*

Chamaesphecia powelli Le Cerf, 1916 (comb. rev.) (figs. 15, 16)

Chamaesphecia powelli Le Cerf, 1916: 15, pl. 321, fig. 4664. Type locality: Algerie, Lambese. Type material: holotype ♀ (MNHP). Heppner & Duckworth, 1981: 37.

Synansphecia powelli: Špatenka, 1992a: 490; Špatenka *et al.*, 1993: 103; de Freina, 1997; 174; pl. 13, fig. 46; pl. 20, fig. 57.

Material examined. Holotype ♀ (fig. 15), with labels illustrated on fig. 16 (NHMP); 2♀, Morocco, High Atlas, Tizi-n-Test, north side, 1900 m, reared from *Nepeta* sp. (Lamiaceae), end of June 1995 e.l., leg. Kallies & Petersen (CMP, CAK).

This species was originally described in the genus *Chamaesphecia* Spuler, 1910 and has been transferred to *Synansphecia* by Špatenka (1992a). However, a revision of the holotype revealed that it belongs in fact to *Chamaesphecia* and is closely related to *Chamaesphecia aerifrons* (Zeller, 1847) and *C. micra* Le Cerf, 1916. Both taxa, *C. powelli* and *C. micra* are likely to represent junior subjective synonyms of *C. aerifrons*. This species uses a broad range of Lamiaceae host plants (Špatenka *et al.*, 1996). Moreover, it is known to be highly variable in wingspan and in the size of the transparent areas of the forewings. However, it is refrained from formal synonymization until more material is known.

In 1996 two ♀♀ from the High Atlas were bred from roots of *Nepeta* sp. (leg. Petersen & Kallies). Both specimens agree perfectly with the holotype of *Chamaesphecia powelli* from Algeria.

Description (♀ holotype, fig. 15). Wingspan 16.0 mm; body length 9.5 mm; forewing length 7.5 mm; antenna 5.5 mm.

Head. Antenna black, scapus white ventrally; frons blackish grey, with white scales medially; labial palpus white, medial joint black distally, apical joint black laterally; vertex black with orange hair-like scales posteriorly; pericephalic hairs orange-yellow.

Thorax. Black; patagia black, orange-yellow ventro-laterally; tegula with orange-yellow inner margin; metathorax with an orange-yellow medial stripe, extending to medial stripes of equal colour on thorax and first tergites of abdomen, respectively.

Legs. Fuscous; fore coxa white, fuscous interiorly; basal half of hind tibia white laterally.

Abdomen. Fuscous, with undefined yellow line mediodorsally; tergite 1 with an orange-yellow spot medially and white laterally; tergite 2 with a few white scales posteriorly; tergites 4 and 6 with narrow white posterior margins; tergite 4 white laterally; sternites 1 and 2 with white scales medially; sternite 4 white laterally; anal tuft black, white baso-laterally and ventro-apically.

Forewing. Fuscous; ETA small, rounded, consisting of four cells, two-thirds as broad as discal spot; ATA short, slightly longer than discal spot; PTA covered with black scales throughout; apical area dark brown black, almost twice as broad as ETA, with single pale ochreous scales between veins; cilia fuscous; ventral side of same colour, but dusted with ochreous scales.

Hindwing. Veins, discal spot and outer margin fuscous; discal spot triangular, reaching M_3; cilia fuscous; similar ventrally, but costal margin and vein M_2 covered with ochreous scales throughout.

Genitalia. Not examined.

Differential diagnosis. No significant differences were found between *C. powelli, C. micra* and *C. aerifrons*. Additional extensive material is necessary to establish the relation between these taxa. *C. powelli* is also similar and related to *C. maurusia* Püngeler, 1912 and *C. anthrax* Le Cerf, 1916. From both it differs by the smaller ETA (with 4–5 cells in the species compared). From *C. anthrax* it can also be distinguished by the wider ATA and PTA. The entire group of species mentioned here should be revised in the future.

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Noctuid moths attracted to fruit baits: testing models and methods of estimating species diversity

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Summary. Using red-wine based baits we sampled 3015 noctuid moths representing 119 species over one season at two sites in northeastern Bavaria. These samples were used to address the question as to whether baiting yields adequate data for analysing the diversity of a moth community. At both sites the samples closely matched the log-series model. The diversity parameter α was estimated as 23–24 in both communities, which is in the range typical for temperate-zone noctuid communities as revealed by light-trapping. Hurlbert rarefaction analyses likewise indicated that both samples were drawn from communities of equal diversity. The numbers of noctuid species and individuals recorded varied strongly between two different bait mixtures and three exposition techniques, but the resulting diversity estimates were not significantly affected. Numbers of species and individuals recorded at baits positively correlated with ambient temperature, but were not affected by wind speed. Estimates of β-diversity showed that both communities had similar species composition, but differed in abundance relationships. Of various estimates of total species richness based on different extrapolation algorithms, the Michaelis-Menten model yielded reasonable, but conservative approximations of "true" species numbers in the communities. Collectively, these results demonstrate that recording noctuid moths at baits provides data perfectly suitable for diversity analysis, as long as effects of sampling effort and sample sizes are controlled for.

Zusammenfassung. An Rotwein-Zucker-Ködern wurden während einer ganzen Vegetationsperiode an 2 Standorten in Nordostbayern 119 Noctuidenarten in 3015 Exemplaren nachgewiesen. Jeder Standort wurde zweimal pro Woche besammelt. Anhand dieses Datenmaterials wurde die Eignung von Köderfangdaten zur Beurteilung der Diversität von Nachtfalterartengemeinschaften geprüft. An beiden Standorten entsprachen die Arten-Abundanz-Verteilungen in sehr guter Näherung dem Modell der logarithmischen Serie. Der Diversitätsparameter α der logarithmischen Serie war mit Schätzwerten von 23–24 an den beiden Standorten gleich groß und lag im Bereich publizierter, aus Lichtfangdaten abgeleiteter Werte für Noctuiden-Gemeinschaften der nördlichen gemäßigten Zonen. Ein Vergleich der Standorte mittels der Rarefaction-Methode nach Hurlbert zeigte ebenfalls, daß die 2 untersuchten Artengemeinschaften in ihrer Diversität übereinstimmten. Zwei verschiedene Ködermischungen und drei Ausbringungstechniken hatten zwar großen Einfluß auf die absolute Anzahl der

nachgewiesenen Individuen und Arten, die resultierenden Schätzungen der Diversität waren davon aber unbeeinflußt. Mit steigender Lufttemperatur nahm auch die Zahl der pro Abend anfliegenden Individuen und Arten zu, Windgeschwindigkeit oder Niederschlag hingegen hatten auf den Köderfang keinen signifikanten Einfluß. Ähnlichkeitsindizes als Maße der β-Diversität zeigten, daß sich die 2 Artengemeinschaften weniger in ihren Artenspektren als in den Abundanzverhältnissen unterschieden. Von mehreren Extrapolationsmethoden zur Schätzung der "tatsächlichen" Artenzahl ergab das Michaelis-Menten-Modell die robustesten, wenn auch konservativsten Werte. Insgesamt zeigen unsere Ergebnisse, daß Köderfangdaten für Eulenfalter in gleicher Weise wie Lichtfangdaten geeignet sind, die Diversität lokaler Artengemeinschaften zu schätzen, sofern die Einflüsse von Aufsammlungsintensität und Stichprobengröße in adäquater Weise berücksichtigt werden.

Résumé. L'utilisation d'appâts au vin rouge a permis d'échantillonner 3015 Noctuidae, représentant 119 espèces, au cours d'une saison sur deux sites du nord-est de la Bavière. Ces échantillons ont été utilisés pour savoir si l'usage d'appâts peut fournir des données satisfaisantes sur l'analyse de la diversité d'une communauté de papillons de nuit. Sur les deux sites, les échantillons se rapportent à un modèle "série-log". Les paramètres de diversité α ont été évalués à 23–24 dans les deux communautés, ce qui est un ordre de grandeur classique pour les communautés de Noctuides en zone tempérée, comme cela a déjà été montré par piégeage lumineux. L'analyse de la raréfaction par le coefficient de Hurlbert semble indiquer que les deux échantillons sont issus de communautés d'égale diversité. Le nombre d'espèces de noctuelles et d'individus recensés varie fortement entre les deux types d'appâts et les trois modalités d'application, mais la diversité résultante exprimée n'est pas significativement modifiée. Le nombre d'espèces de noctuelles et d'individus recensés par les appâts est positivement corrélé à la température ambiante, mais non affecté par la vitesse du vent. L'estimation de la diversité β montre que les deux communautés ont des compositions spécifiques similaires mais diffèrent par les critères d'abondance. Parmi plusieurs estimations de la richesse totale basées sur plusieurs extrapolations algorithmiques, le modèle Michaelis-Menten paraît raisonnable, et compatible avec l'approximation modérée du "vrai" nombre d'espèces dans les communautés. Globalement, ces résultats démontrent que les méthodes de capture des noctuelles par appât donnent des résultats parfaitement valables pour l'analyse de la biodiversité, aussi longtemps que l'effort d'échantillonnage et que la taille des échantillons seront contrôlés.

Key words: Lepidoptera, Noctuidae, biodiversity, research methods, traps, baits, Bavaria, Germany.

Introduction

With an estimated richness of 150,000–250,000 extant species (Heppner, 1991), the Lepidoptera comprise a sizeable, yet comparatively well known fraction of biotic diversity on Earth. It is thus not surprising that many studies use butterflies or moths as model organisms for biodiversity research. A critical issue for

all such studies is the reliability and usefulness of any measures of "biodiversity" which can be derived from samples of real communities. Such samples are, by necessity, incomplete and influenced by a large (and often unknown) number of extrinsic factors. For example, unpredictable weather conditions and stochastic variation in abundance of species in communities all contribute to sampling error (Mawdesley, 1996).

For nocturnal moths, attraction to artificial light sources is the most commonly used method of sampling, although pheromone traps or other techniques have also been applied (reviewed in Muirhead-Thomson, 1991). It is well established that moth samples from light traps can be described, with reasonable accuracy, using mathematical models such as the logarithmic series (Fisher *et al.*, 1943) or the log-normal distribution (Preston, 1948). Therefore, such models have been widely and successfully applied to the analysis of moth communities from temperate (Kempton & Taylor, 1974) as well as tropical regions (Robinson & Tuck, 1996).

As early as the last century it was observed that certain moths (mainly in the family Noctuidae) can be attracted with liquids containing sugar (e.g. Steiner & Nikusch, 1994). Such artificial baits imitate natural food sources, like rotting fruits, honeydew, or sap oozing out of wounded trees. For a useful bait mixture many recipes have been described (Steiner & Nikusch, 1994), but the main ingredients are always similar. A bait is offered that provides the scent of a solution containing sugar, alcohol, and volatile compounds such as esters which naturally occur in rotting fruits. A variety of techniques has been suggested as to how to offer baits. The commonest ways of presentation are patches of liquid bait directly applied to trees or poles, or suspending materials (strings, pieces of fabric, dried fruits) which have been soaked with the liquid bait mixture (Lederer, 1959; Nippel, 1976).

Baiting has been extensively used for faunistic inventories in the past. Hartwieg (cited in Cleve, 1971), for example, recorded between 1904 and 1956 nearly 80% of the noctuid species which occur in the region of Braunschweig (north-central Germany) by baiting. When baiting and light trapping are done simultaneously, moths of some noctuid genera (e.g. *Amphipyra, Conistra, Agrochola* or *Catocala*) often appear at the baits in much larger

numbers (Cleve, 1971; Mörtter, 1988), suggesting that estimates of abundance based on light-trapping results alone can be misleading. Hence Steiner & Nikusch (1994) postulated that for a "complete" faunistic or ecological inventory of the moth fauna of any given site it is necessary to combine both recording techniques. For practical purposes (e.g. nature conservation: Meineke, 1995), light-trapping seems to be the superior way of monitoring since it usually yields larger samples with smaller time effort, covers a broader range of nocturnal moth taxa, and elaborate methods of analysis have been developed (Southwood, 1978; Robinson & Tuck, 1996).

Light-trapping, however, is based on an artificial stimulus, and the behavioural mechanisms underlying the attraction of moths to UV-light sources are still not satisfactorily understood (Butler & Kondo, 1991; Muirhead-Thomson, 1991). Hence, any sampling method which makes use of a more natural behavioural context, such as the search for food resources in the case of baiting, might have the potential to reveal ecological community patterns more accurately. In fact, bait-traps are now widely used in studies on the community ecology of fruit-feeding nymphalid butterflies in tropical realms (DeVries *et al.*, 1997). We therefore set out to investigate whether recording moths at baits over one entire season in a northern temperate zone may yield adequate samples for quantitative assessments of the diversity and richness of the noctuid guild attracted to such food resources.

Most published papers, which we are aware of, present results of bait-trapping moth surveys only in a qualitative manner, e.g. as species lists (Nippel, 1976; see Kozlov *et al.*, 1996 for one of the rare exceptions). At most these lists are supplemented with subjective assessments of relative abundance ("rare", "common"). Although most authors offer numerous, and often contrasting, subjective opinions as to how weather conditions may influence the attraction of moths to baits, or which method of presenting the bait (or preparing bait mixtures) may be most effective, practically no quantitative tests of these factors have been carried out thus far. Instead, even the proponents of baiting for faunistic studies appear to assume, at least by implication, that baiting as a sampling method is inherently subject to so much variation that its results can neither be compared between studies, nor used for more than supplementary or qualitative information (Steiner & Nikusch, 1994).

In this paper we explicitly address some questions relevant to the usefulness of bait-trapping as a method of assessing moth diversity:

1. How well do samples of noctuid moths assembled at baits correspond with the log-series model?
2. Can the log-series model, or rarefaction methods, be used to quantitatively describe and compare species diversity (α-diversity) of samples from different communities?
3. Can similarity indices (as a measure of β-diversity) successfully be applied to such samples?
4. How do various estimates of absolute species richness perform when applied to our data set?
5. Are the results obtained with different baits, or techniques, after all comparable? More precisely, this relates to the question as to whether samples obtained with different baits, or different exposition methods, yield corresponding estimates of diversity of the community from which the samples have been drawn.
6. How large is the influence of abiotic factors like temperature and wind speed on the success of bait-trapping?
7. How strongly are the estimates of diversity affected by sample size (i.e. numbers of recorded individuals) or sampling effort (i.e. recording nights per habitat)?

The results presented here strongly support the idea that, much the same as with light-trapping, data obtained by baiting can be used for estimating diversity of noctuid moths, if sufficiently large samples are obtained with a standardized sampling regime.

Materials and methods

Study sites. For our study we selected two sites near Bayreuth (Germany, north-eastern Bavaria). Both were chosen so as to represent typical habitats in a central European cultural landscape, rather than habitats where a particularly rich fauna would be expected. The first site is situated in the botanical garden (BG hereafter) of the University of Bayreuth (355 m a.s.l.) and is mainly characterized by large, almost plain meadows (ranging from moist to moderately dry), interrupted by small stands of young trees and a couple of ponds. The nearest closed forest is situated approximately 600 m to the south, while 300 m to the west an allotment area continues. At this site the bait lines and patches were installed at the south-facing edge of a small

stand of scots pine (*Pinus sylvestris*) and spruce (*Picea abies*) approximately 5 m high and 15 years old.

The second site was situated 5 km southeast of Bayreuth near Wolfsbach. The meadow at the Schlehenmühle (400 m a.s.l., SM hereafter), located on an east-facing slope to the river Roter Main, is much smaller in comparison to the botanical garden and is largely surrounded by closed woodland. The forest mainly consists of pine and spruce, but is at the edge interspersed with deciduous trees. The understorey (blueberry (*Vaccinium myrtillus*) and grasses) is sparse due to the very dense canopy. The vegetation along the river bank consists mainly of black alder (*Alnus glutinosa*) and a few oak trees (*Quercus robur*). The bait lines and patches were placed along the forest edge. Due to its facing the river, the microclimate of the Schlehenmühle site is colder and more humid than in the botanical garden.

Field Methods. We used two different bait mixtures. For the sugar mixture 500 g sucrose were dissolved in approx. 200–300 ml red wine in a glass of 600 ml volume. For the same amount of banana mixture we mixed 400–500 g of mashed bananas with 200–300 ml red wine. Bait mixtures were prepared about 4 d before first use, and were subsequently used for 3–5 d. The idea behind these two bait mixtures was that the sugar mixture may provide a carbohydrate resource suitable for a range of generalist moth species, whereas the banana mixture might preferably be used by species which regularly feed on ripe or rotting fruits.

Two different ways were used to expose the bait. Either liquid bait was painted in patches (size approx. 10×15 cm^2) on tree trunks at a height of 50 or 200 cm ($n = 16$ each), respectively. Alternatively, we tightened a string (length approx. 6 m) at a height of 200 cm between two trees from which we suspended pieces of cotton cloth (size approx. 10×15 cm^2, $n = 20$) soaked with the liquid bait. We expected that the latter way of bait exposition should attract a larger number of moths because the scent plume would diffuse freely in all directions. With both presentation techniques the two bait mixtures were alternated regularly so as to minimize potential positional bias in their attractiveness.

On each sampling night the baits were exposed freshly around sunset. Then, all baits were checked for the presence of moths every 30 min over a period totalling 3 h. The first check of the

baits took place in early dusk, i.e. after being exposed for approx. 30 min. The timing of the sampling throughout the season was standardized so that each evening the second check round at the baits invariably occurred at a light intensity of <10 lx (Bioblock Scientific, LX-101). At the beginning of each check, air temperature and wind speed at a height of 200 cm were measured (anemometer: Testoterm-Technovent 4000). For each sampling night, all temperature and wind speed data were averaged to provide a single rough measure of these important climatic data for subsequent analyses.

All moths encountered during each round were captured for identification (using Skou (1991) as principal reference work, supplemented by special papers where needed) and to avoid multiple counts. The complete species list and abundance data have been published elsewhere (Süssenbach & Fiedler, in press). In all analyses presented here, only species of the family Noctuidae were included.

The first sampling occurred on 01.IV.1997 and the last one on 10.X.1997. At each study site samples were taken twice a week, resulting in a database of 106 nights (53 per locality).

Data analysis. Many quantitative measures have been developed to assess "diversity" of ecological communities (Southwood, 1978; Magurran, 1988; Krebs, 1989; Mawdesley, 1996). As a measure for *α-diversity* (diversity within a habitat, or sample) we here use *Williams' α* which is derived from the "*logarithmic series*", or log-series (Fisher *et al.*, 1943). This mathematical model (see Hayek & Buzas, 1997 for a general introduction and multiple references to further applications) describes the distribution of individuals across species, and in particular accounts for the well known observation that in natural communities there are usually only very few "abundant", but a large number of "rare" species. According to this model, species number (S) and number of individuals (N) in a sample are related to each other as:

$$S = \alpha \log_e \left(1 + \frac{N}{\alpha}\right)$$

where α can be interpreted as an index of diversity. To allow for comparisons between samples the 95% confidence limits are calculated:

$$CI_{95\%} = a \pm t_{95\%} \sqrt{\text{var } a}$$

with the estimate of variance being:

$$\text{var } a = a^3 \frac{(N + \alpha)^2 \log_e \left(\frac{2N + a}{N + a} \right) - Na}{(SN + Sa - Na)^2}$$

where $t_{95\%} = 1.96$ is the two-tailed threshold value of statistical significance of Student's t-distribution at the selected significance level (here: $p < 0.05$) for an infinite number of degrees of freedom (Sachs, 1992). a and x were calculated using the program "*logserie*" of Krebs (1989), while var α was calculated using the formula originally derived by Fisher *et al.* (1943). We chose this variance estimate, instead of the widely used Anscombe estimate, because for large samples (i.e., in the hundreds, as ours) its mathematical properties are superior (Hayek & Buzas, 1997).

Williams' α provides a measure of diversity that is particularly robust over a wide range of conditions as long as sample sizes are sufficiently large (say, ≥100 individuals: Hayek & Buzas, 1997). We test the goodness-of-fit between the log-series model and our empirical data using the Pearson correlation coefficient r between the observed and expected abundances (the latter are expressed as the Whittaker plot by the program "*logserie*"). In addition, we compare the observed and expected numbers of species in abundance classes (scored in octaves: Preston, 1948) using χ^2 statistics.

An alternative way to compare species diversity between samples of communities are the "*rarefaction methods*" (Hurlbert, 1971; Achtziger *et al.*, 1992; note that also the log-series model can be used to rarefy if one assumes it to accurately describe a community: Hayek & Buzas, 1997). Generally, it is invalid to simply compare absolute species numbers between samples unless the sample sizes are equivalent, because with increasing sample size the number of recorded species also increases due to stochastic effects, even if the samples are drawn from the identical community. The Hurlbert rarefaction allows the comparison of species numbers between samples where the total numbers of individuals are different: the larger sample(s) can be rarified to the smallest sample size, and an expected species number can

be calculated (together with a confidence interval: Simberloff, 1978) for any fixed sample size. Note that extrapolation from Hurlbert rarefaction curves is invalid (Müller-Schärer *et al.*, 1991). The necessary calculations were made with the program "*rarefact*" of Krebs (1989).

While diversity indices such as Williams' α, or the rarified expected species richness for a given sample size, provide mathematically 'exact', but rather abstract figures, it might often be interesting to know about the 'absolute' number of species which make up a given community. Since complete inventories are practically always impossible to achieve (from statistical reasons alone), one may use *extrapolation methods*, which estimate the total number of species from empirical samples. Recent advances in mathematical methodology have provided a set of extrapolation procedures that are in part based on relatively complicated formulae and rather different assumptions (see Colwell & Coddington, 1994). These algorithms estimate species richness either from extrapolation of randomized species accumulation curves (e.g. Michaelis-Menten model, where a hyperbolic function is fitted, whose asymptote serves as richness estimator), or they derive an estimate from the 'rare' species in the sample, because it is most likely that all species not yet covered by sampling would belong to these lowest abundance categories (see Colwell & Coddington, 1994 for further discussion and references). An important difference between such extrapolation methods and the log-series is that mathematical models underlying extrapolation procedures are usually asymptotic (i.e. converge to a 'true' value of total species richness, if sampling effort increases), whereas the log-series does not have an asymptote.

We have here chosen five different estimators. First, a Michaelis-Menten model was fitted to the sampling data (after randomizing them 50 times, using the *MMMeans* procedure of Colwell, 1997). Michaelis-Menten type models describe well the accumulation of species records as sampling increases, with steadily increasing likelihood of adding new species (Lamas *et al.*, 1991). Second, four estimators which emphasize the 'rare' species in the samples were used. The two versions of Chao's estimator (based on those species which occur in only one or two specimens in the entire sample: *Chao1*; based on species which occur in only one or

two sampling nights: *Chao2*) are particularly easy to calculate and have produced promising results in recent empirical tests (León-Cortés *et al.*, 1998; Peterson & Slade, 1998). Two coverage estimators (abundance-based: *ACE*, incidence-based: *ICE*) were also included because of their promising mathematical features (Lee & Chao, 1994; Colwell, 1997), although we are unaware of any experiences with real biological data sets published so far. *ACE* is based on all species represented with 10 or fewer individuals in the total sample, while *ICE* uses all species represented in 10 or fewer sampling nights.

The calculations were done with the program *'EstimateS5'* (Colwell, 1997; where also the formulae for *ACE* and *ICE* and the variance estimates can be found). The definitions of *Chao1* and *Chao2* are as follows:

$$\hat{S}_{Chao1} = S_{obs} + \frac{F_1^2}{2F_2})$$

$$\hat{S}_{Chao2} = S_{obs} + \frac{Q_1^2}{2Q_2})$$

where S_{obs} is the number of species observed; F_1 the number of species represented by one specimen only (i.e. singletons); F_2 the number of species represented by two individuals only; Q_1 the number of species which occur in exactly one sample (i.e. found in just one collecting night); and Q_2 the number of species represented in just two samples. Confidence intervals were calculated using the standard deviation estimates produced by the program, multiplied with the 95% threshold value of the t-statistics (1.96).

We also wanted to know whether baiting samples of noctuids are suitable for differentiation between communities. For that purpose, we calculated similarity indices as measures of *β-diversity* (between-habitat diversity). In the ecological literature a plethora of similarity indices have been proposed, many of which have serious drawbacks (Wolda, 1981; Lande, 1996). Basically similarity indices can be divided in two classes: binary measures which only take into account the presence or absence of species, and others which also use abundance information.

We have selected two binary indices (the Sörensen or Czekanowski index, and the Dice or association index), and two abundance-based measures (Morisita and Renkonen index). Of the binary indices, Sörensen similarity has been widely used in community ecology. The Dice index can be advantageous if one sample is much smaller than the other, but this difference is largely due to sampling efficiency (and not an ecological property of the community: Wolda, 1981). Of the two abundance-based measures widely used, Morisita's index seems to be particularly suitable for most ecological comparisons (Wolda, 1981; Magurran, 1988).

To assess differences between samples in relation to bait mixture or method of bait presentation, we apply elementary statistical procedures (χ^2 contingency tests) in addition to the diversity measures detailed above. The influence of temperature and wind speed on sampling efficiency is tested by standard correlation techniques.

Finally, we will address the question as to how sampling effort (i.e. number of sampling nights) influences the results. We have selected two approaches. First, we apply the Shinozaki rarefaction method (Achtziger *et al.*, 1992) which yields estimates for the expected number of species to be observed as a function of the number of sampling units (here: baiting nights). Calculations were made with a program written by W. Achtziger (cf. Achtziger *et al.*, 1992). Second, we compare our results on diversity and species richness between subsets of our samples. Because we sampled both sites twice a week, a simple way of obtaining two subsamples for each site was to use either only the results of the first, or alternatively the second, sampling night per site and week.

Results

Structure, α-diversity and similarity of the two moth communities. During the entire sampling period in 1997 we recorded 106 noctuid species with 1976 individuals at site BG, and 88 species with 1039 individuals at site SM (species lists and abundance data in Süssenbach & Fiedler, in press). While the absolute abundances of moths at both localities obviously differed strongly, the rank-abundance plots showed a very similar shape. There were only a few very frequent and many rare species. At BG, 39.6% of the species were singletons or doubletons, representing

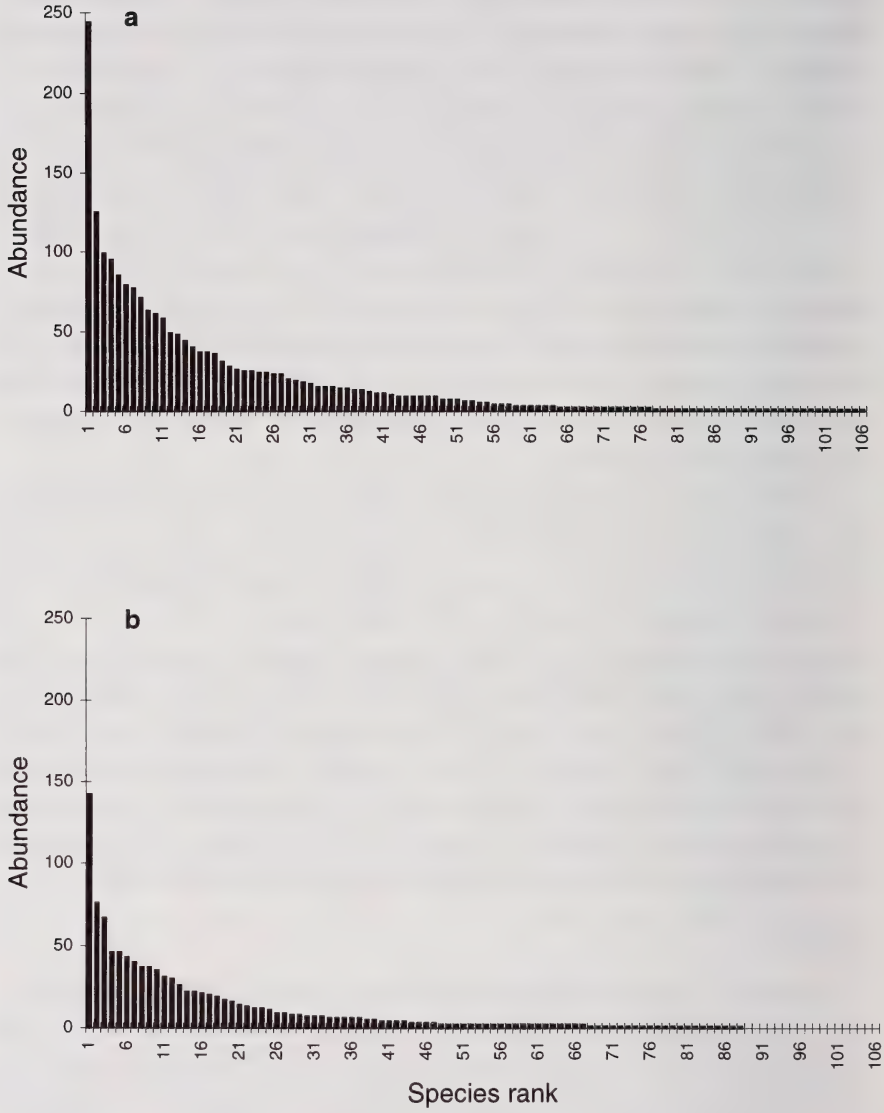
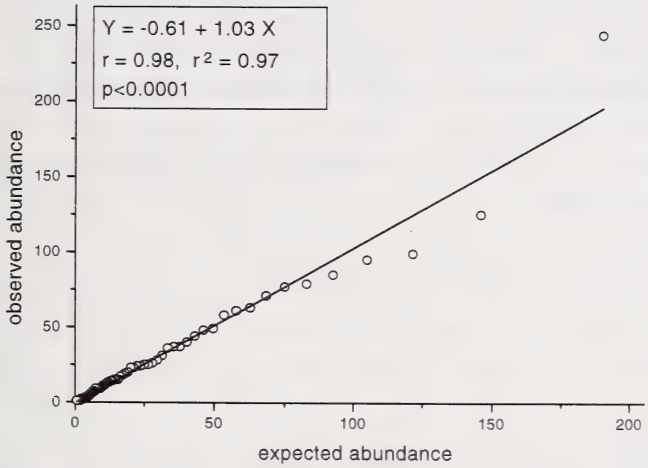


Fig. 1. Rank-abundance plots of the noctuid moth communities attracted at baits in the botanical garden BG (a) and at the Schlehenmühle SM (b).

a)



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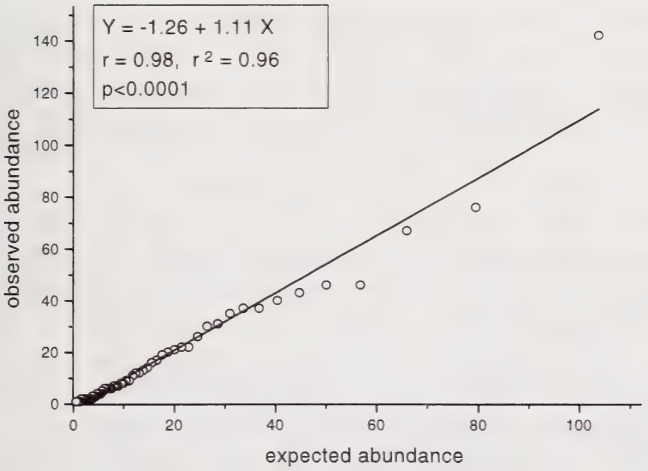


Fig. 2. Correlation between recorded abundance (Y-axis) and expected values (X-axis; from the Whittaker plot) under the log-series model, for the species community at the botanical garden BG (a) and the Schlehenmühle SM (b). At both sites observed and expected values are highly significantly correlated.

but 2.8% of all individuals. The respective proportions at SM were 46.6% of species, and 5.9% of individuals.

The empirical rank-abundance distributions closely match the log-series model (fig. 2). At both sites, observed and expected frequencies correlate highly significantly. Only for the most dominant species does the log-series model underestimate the observed abundance. Moreover, at both sites the observed numbers of species in abundance octaves closely matched predictions based on the respective parameter estimates of α and x (BG: $\chi^2_{6df} = 4.36$, $p > 0.62$; SM: $\chi^2_{6df} = 3.62$, $p > 0.72$). Therefore, the noctuid communities attracted at baits can be very well described by the log-series model, and accordingly Williams' α provides a reasonable measure of the diversity of both communities. The α-values were 23.96 ± 2.29 for site BG, and 22.95 ± 2.67 for site SM, with strong overlap of the confidence intervals.

Application of the Hurlbert rarefaction method yields analogous results (fig. 3). The curves for the two sites are almost completely congruent. Rarefaction of the larger sample (BG) to the size of the smaller sample (1039 individuals, as at the site SM) reveals that the expected number of species at both localities is identical. Collectively, the α-values and rarefaction curves for both sites strongly indicate that, in spite of the differences in the recorded numbers of species and individuals, the structure and α-diversity of both communities of noctuids attracted to baits are virtually identical.

The results of various extrapolations of the 'true' species richness from our empirical data are summarized in Table 1. Included here are four estimators which rely largely on rare species (*ACE, ICE, Chao1, Chao2*) and one estimator based on the Michaelis-Menten model (*MMMeans* (fig. 3); see Colwell, 1997). These estimators uniformly indicate that, as expected, the communities of noctuid moths which could have been attracted to baits were not exhaustively covered during our survey. For the BG site estimators based on rare species indicate that the fauna comprised 135–145 species, of which only 73.1–78.5% have actually been sampled. According to the Michaelis-Menten model (with a lower asymptote of 123 species), 86.2% of the expected fauna has been recorded within one single season of baiting. At

the SM site all estimators converge between 99 and 108 species, which implies that the local community has been sampled with a coverage of 81.5–88.9%.

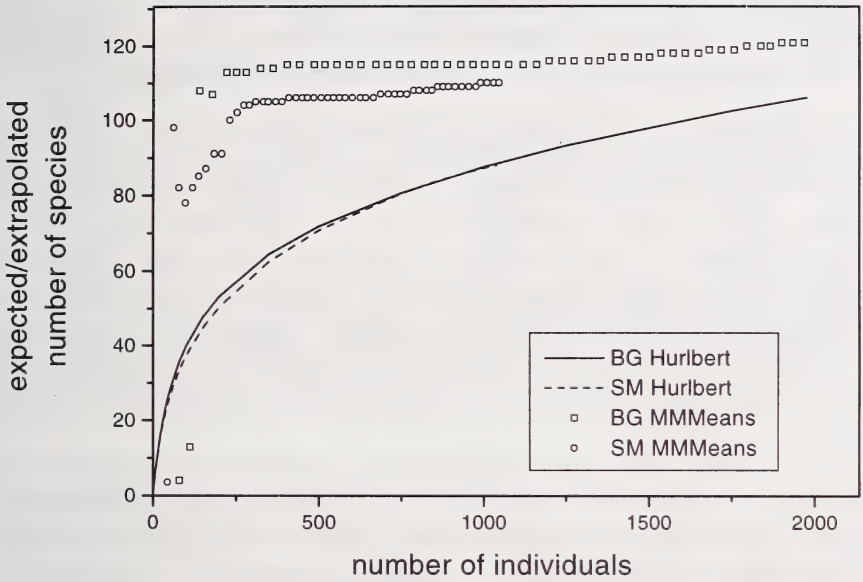


Fig. 3. Hurlbert rarefaction curves for the baited noctuid communities of the botanical garden and the Schlehenmühle, and performance of Michaelis-Menten richness estimators (MMMeans) as a function of randomized sample accumulation.

Table 1. Estimated "total" number of species (±95% confidence intervals where applicable) at the two sampling sites as revealed by different extrapolation algorithms (see Colwell, 1997)

Species richness estimator	Botanical Garden (BG) "Total" species number	Botanical Garden (BG) Percent observed of estimated total	Schlehenmühle (SM) "Total" species number	Schlehenmühle (SM) Percent observed of estimated total
ACE	144	73.6	107	82.2
ICE	135	78.5	108	81.5
Chao1	138±31	76.8	99±12	88.9
Chao2	145±35	73.1	102±14	86.3
MMMeans	123	86.2	106	83.0

The second column for each site gives the proportions of the actually recorded number of species (BG: 106; SM: 88) as percentages of the respective estimator for "total" species richness.

The communities of noctuids attracted to baits at the two sites were remarkably similar. Overlap in species composition was 0.77 (Sörensen index) to 0.85 (Dice index). When abundance data were included, the communities could be separated more clearly (Morisita index: 0.60, Renkonen index: 0.55). These data suggest that, with regard to bait-feeding noctuids, the two study sites differed in relative abundance and dominance characteristics of the component species, but less so in species composition.

Comparison of different bait mixtures and between methods of bait presentation. One central aim of our study was to test if and how the choice of bait mixtures or presentation techniques affects the noctuid samples attracted to the baits. For these analyses data of both study sites were combined since we have shown above that diversity of both communities was identical and species compositions did not differ markedly. In addition, Williams' α for the combined BG + SM sample ($\alpha = 24.73 \pm 2.11$) is not significantly different from the parameter estimate for each site.

As a first step, we compared the numbers of species and individuals attracted to the two bait mixtures (only considering moths attracted to suspended baits), the effectiveness of exposing the bait (at the same height, 200 cm) on tree trunks *vs.* suspended pieces of cloth, and the influence of presentation height at a tree trunk (50 *vs.* 200 cm). All these factors strongly (and in 5 out of 6 comparisons significantly) affected sampling efficiency (Table 2). Almost twice as many species, and almost ten times the number of individuals, were attracted to the sugar rather than the banana bait mixture. Exposing baits on freely suspended pieces of cloth attracted twice as many individuals and slightly increased the number of recorded species, as compared to painting the bait on tree trunks at the same height. Baits exposed at a height of just 50 cm were the least effective.

So, different baiting mixtures and techniques heavily influenced the absolute numbers of recorded individuals and species. If the diversity of samples is considered, however, these methodological differences largely disappear. The values of Williams' α are practically identical for all subsamples (Table 2). Likewise, Hurlbert rarefaction curves reveal a remarkably high correspondence between the two bait mixtures as well as among the various

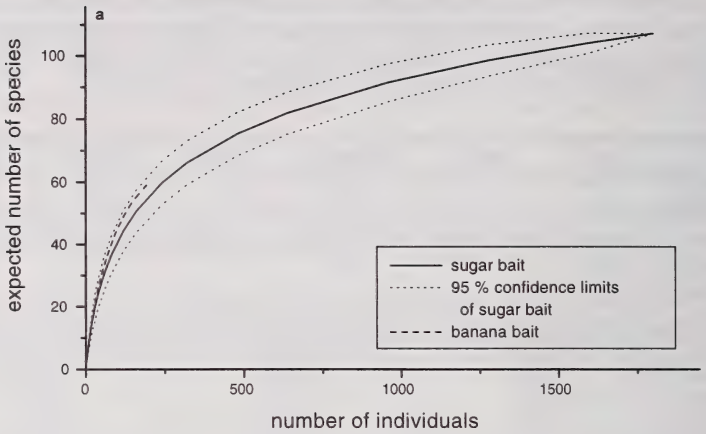
Table 2. Comparisons of recording efficiency between the two bait mixtures (sugar *vs.* banana; suspended baits only), and between methods of bait presentation (suspended *vs.* painted on tree trunks, height 200 cm (= "tree200"); painted on tree trunks, 50 (= "tree50") *vs.* 200 cm)

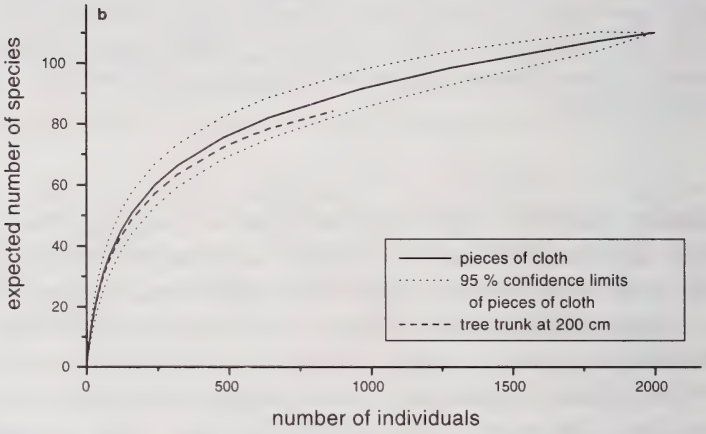
	Sugar	Banana	Suspended	Tree200	Tree200	Tree50
Number of individuals	1800	193	1993	866	866	144
Statistics	$\chi^2_{1df} = 1295.8$, $p < 0.0001$		$\chi^2_{1df} = 444.3$, $p < 0.0001$		$\chi^2_{1df} = 516.1$, $p < 0.0001$	
Number of species	107	59	110	84	84	47
Statistics	$\chi^2_{1df} = 13.88$, $p < 0.001$		$\chi^2_{1df} = 3.49$, $p > 0.05$		$\chi^2_{1df} = 10.45$, $p < 0.005$	
$\alpha \pm 95\%$ CI	24.92 ± 2.43	28.97 ± 6.47	25.04 ± 2.37	22.97 ± 2.83	22.97 ± 2.83	24.26 ± 6.28
Sörensen	0.699		0.814		0.595	
Dice	0.983		0.941		0.830	
Morisita	0.911		0.804		0.520	
Renkonen	0.887		0.698		0.673	

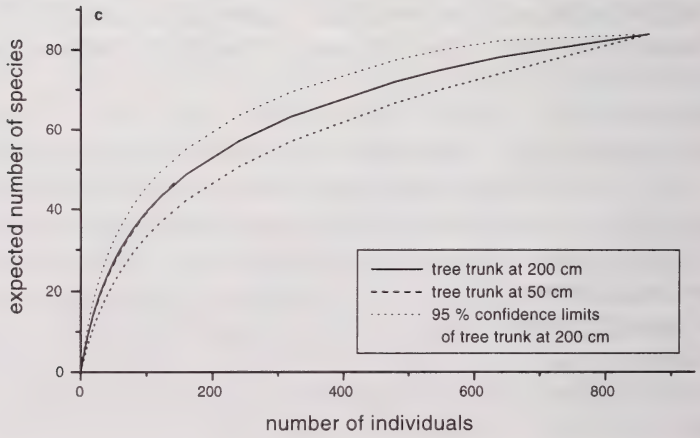
Statistical comparisons between numbers of species or individuals are made with χ^2-tests (null hypothesis: equal distribution between methods). As a measure of sample diversity, values of Williams' α of the log-series (with 95% confidence interval, CI) are presented. Similarity between subsamples is expressed as Sörensen, Dice, Morisita, and Renkonen indices.

presentation methods (fig. 4). In no case do the expected species numbers differ significantly between the larger sample (when rarified) and the smaller sample. Furthermore, the subsamples were all quite similar with regard to their species composition and abundance relationships. The Dice index (which is the most appropriate binary index here since samples of different species richness are compared, but differences are due to sampling efficiency) reveals a correspondence between 83 and 98.3%. Also the abundance-based Morisita and Renkonen indices indicate similarities between 52 and 91%.

Examination at species level showed that none of the more common species (i.e. represented by more than five individuals in our total sample) was exclusively observed at the banana bait or with only one specific method of bait presentation. Only four species (*Agrochola litura, Euplexia lucipara, Phlogophora meticulosa* and *Polia nebulosa*) were exclusively caught at the sugar bait. Given the overall much lower attractiveness of the banana bait, however, this is probably a stochastic effect of sample size rather than a hint towards specific avoidance of the banana mixture.


a
expected number of species
number of individuals
sugar bait
95 % confidence limits of sugar bait
banana bait


b
expected number of species
number of individuals
pieces of cloth
95 % confidence limits of pieces of cloth
tree trunk at 200 cm

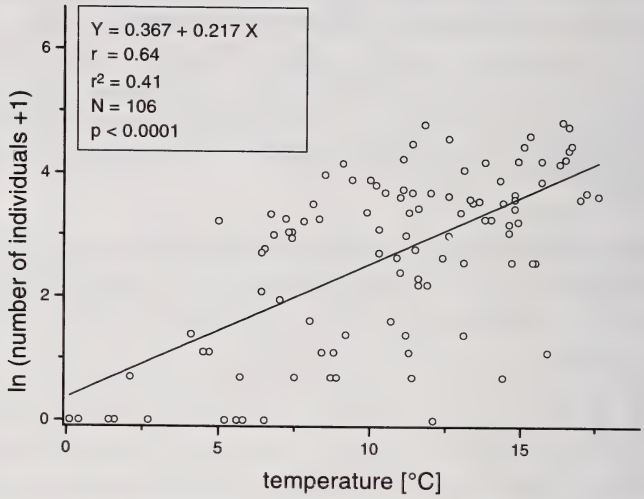

c
expected number of species
number of individuals
tree trunk at 200 cm
tree trunk at 50 cm
95 % confidence limits of tree trunk at 200 cm

In sum, although we found considerable variation in the effectiveness of attracting moths depending on bait mixture or baiting method, there was no evidence that either bait type or method drew significantly different subsamples from the community of noctuid species which frequent such baits. The similarity between the subsamples was high, and estimates of α-diversity (based on Williams' α or Hurlbert's rarefaction method) provided entirely concordant results, irrespective of methodological details.

Influence of weather conditions on baiting success. Most moths are ectothermic animals that depend on appropriate climatic conditions (e.g. temperature) for maintaining flight activity. Even though certain noctuids which are active in winter possess elaborate methods of thermoregulation (e.g. *Lithophane, Eupsilia*: Heinrich & Mommsen, 1985), one should expect that overall attraction of noctuids to baits is strongly influenced by temperature. Wind speed might also interfere with the efficiency of bait-trapping. On the one hand, higher wind speed and concomitant stronger convective cooling should constrain flight activity, in particular at lower air temperatures. On the other hand, the scent plume of baits might distribute more freely, and reach further, if carried by air currents. We tested the influence of both climatic variables on the number of individuals and species attracted to the baits. For these tests we combined data from both localities and for all bait mixtures or presentation methods, and then calculated the Pearson correlation coefficient between the total nightly catch and the average temperature and wind speed score for the respective evening.

←Fig. 4. Hurlbert rarefaction curves for the comparison of samples (a) sugar *vs.* banana bait, (b) suspended pieces of cloth *vs.* bait painted on tree trunk (height 200 cm), and (c) bait on tree trunks (200 cm *vs.* 50 cm). In all three cases, the rarefaction curve of the smaller sample lies completely within the confidence limits of the rarefaction curve of the larger sample, i.e. the diversity of samples is not significantly different.

a)



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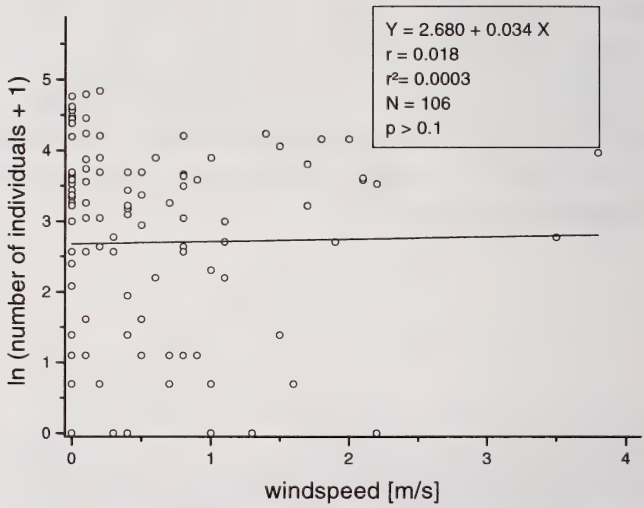


Fig. 5. Relationship between the number of individuals caught at baits (transformed as ln(x+1)) and (a) temperature or (b) windspeed.

We found a significant positive correlation between the number of attracted moths and temperature (fig. 5a). A similar relationship was found between temperature and recorded number of species ($r = 0.68$, $r^2 = 0.46$, $p < 0.0001$). In contrast, wind speed had no detectable influence on the number of arriving moth individuals (fig. 5b), nor species ($r = -0.040$, $r^2 = 0.002$, $p > 0.1$), although the largest samples were taken on evenings with little wind.

Assessing the intensity of recording. As shown above, baiting noctuids at the two study sites twice a week over an entire season yielded a large, robust database, from which the diversity and species richness of the moth communities could be reliably estimated. However, this recording scheme required an immense time effort. To assess how well the communities could be described with only half the recording effort, we partitioned our samples from both sites into two subsamples. Subsample 1 consisted of only the first recording night per week at each of the localities, subsample 2 only of every second recording night per week per site. Both of these subsets of data were then compared with each other and with the complete data set. As expected, with half the sampling effort we recorded at both sites roughly half of the individuals, and approximately 70–80% of the species (Table 3). By chance, the subsample SM1 was distinctly poorer than SM2.

Table 3. Numbers of species and individuals in the subsamples and in the complete set of data for each study site

	Botanical Garden (BG)			Schlehenmühle (SM)		
	BG1	BG2	total	SM1	SM2	total
Number of species	89	86	106	65	76	88
Number of individuals	1054	916	1976	493	553	1039

Williams' α of the log-series reveals that α-diversity neither differed significantly between the subsamples at any site, nor between any subsample and the corresponding total catch (fig. 6). Similarly, the Hurlbert rarefaction method (based on recorded

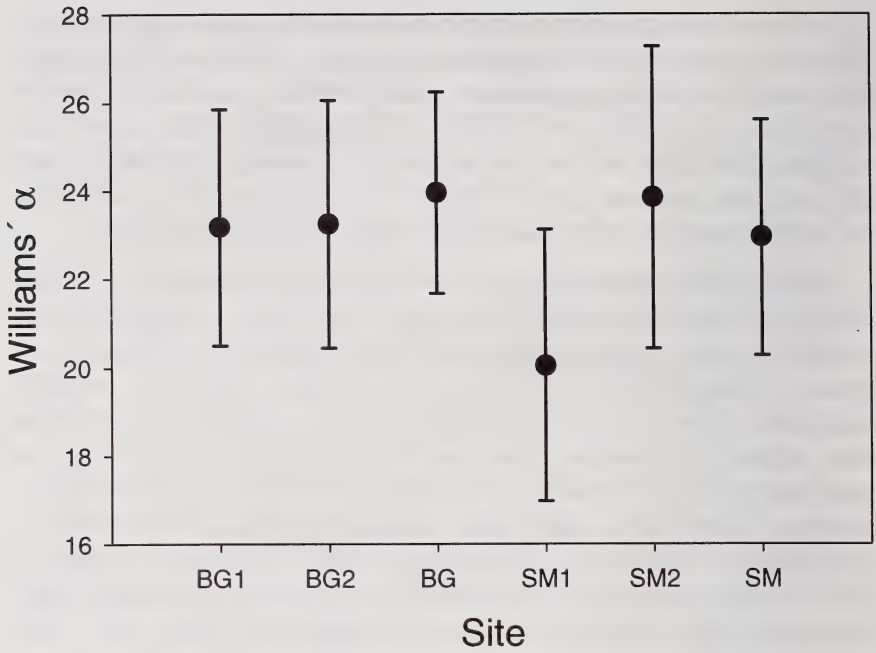
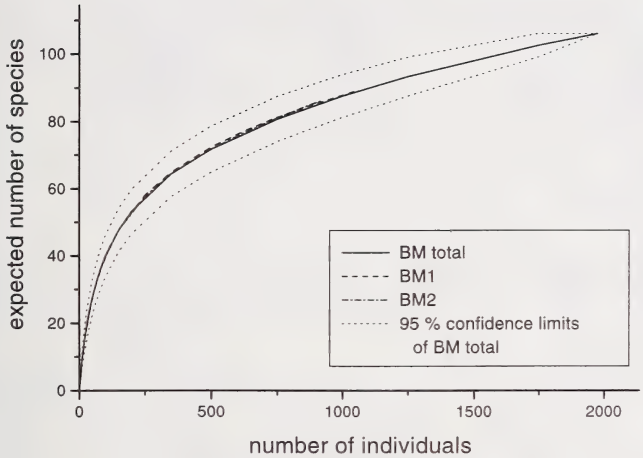


Fig. 6. Williams' α of the log series (± 95% confidence intervals) for the subsamples and the complete set of data for both study sites (BG, SM).

individuals: fig. 7) as well as the Shinozaki rarefaction method (based on sampling nights: fig. 8) show that at both study sites the two subsamples agree very closely with each other, as well as with the rarefaction curves for the entire data set. Hence, α-diversity and community structure of the noctuid moths attracted to baits could have been assessed with equal reliability through only one sampling event per week. Not only diversity, but also species composition was very similar between the two subsamples at each study site. The Morisita index, in particular, revealed a very close correspondence between the data subsets.

With reduced sampling effort, one invariably misses an increasing proportion of the species present in a community (Table 3, figs. 7 & 8). Therefore, it will become more and more difficult to estimate the 'true' species richness. An empirical approach to assess the potential of estimating absolute species richness from reduced samples is the application of the extrapolation estimators

a)



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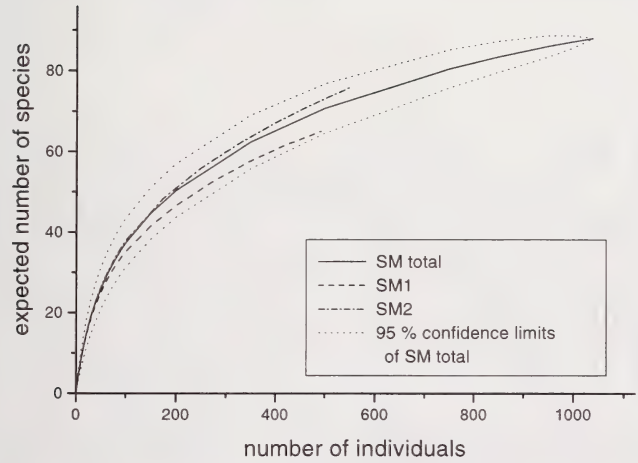

Fig. 7. Hurlbert rarefaction curves of the entire baiting samples of noctuids, and the corresponding subsamples, for both study sites (a: BG, b: SM). The rarefaction curves of the subsamples lie entirely within the 95% confidence limits of the rarefaction curve for the whole data set, indicating that diversity did not differ between subsamples, nor between any subset and the complete data set.

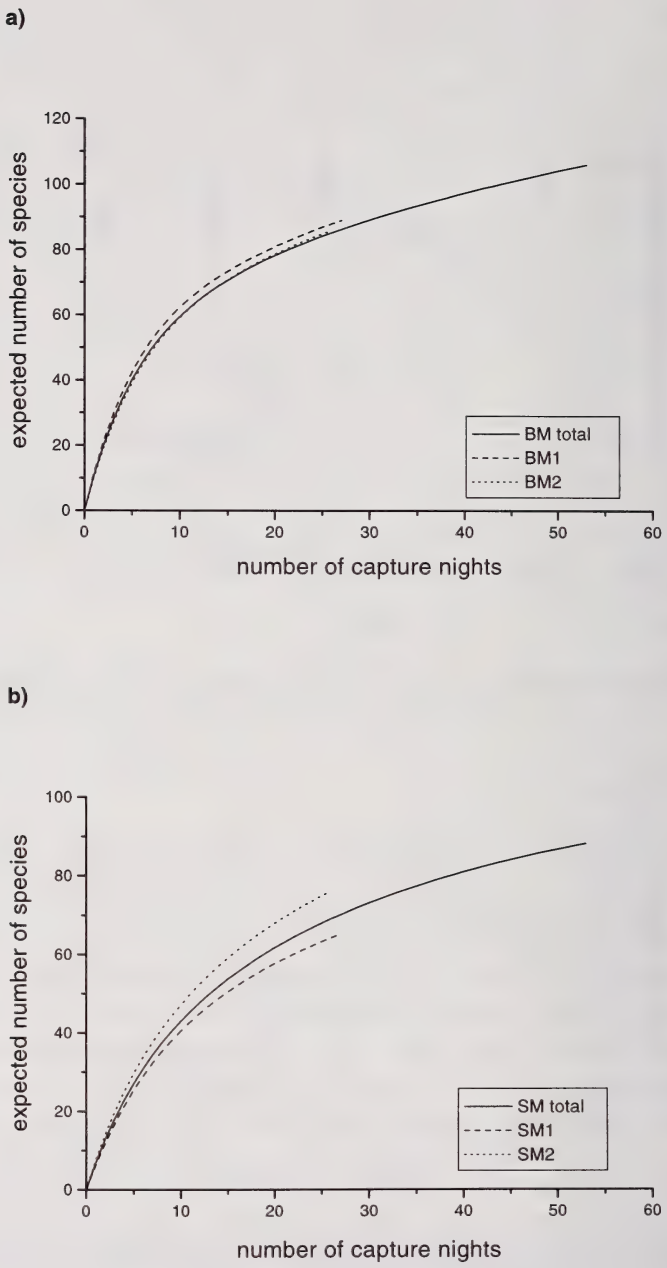

Fig. 8. Shinozaki rarefaction curves of the entire baiting samples of noctuids, and the corresponding subsamples, for both study sites.

Table 4. Indices for the comparisons between subsamples for each study site

	BG1/BG2	SM1/SM2
Sörensen	0.79	0.75
Dice	0.80	0.82
Morisita	0.96	0.94
Renkonen	0.84	0.77

Table 5. Performance of the estimators (±95% confidence intervals where applicable) of "absolute" species richness (Colwell, 1997) based on the partitioned subsamples collected at both sites

Species richness estimator	Botanical Garden (BG)		Schlehenmühle (SM)	
	BG1	BG2	SM1	SM2
ACE	112 (–22.2%)	115 (–20.1%)	92 (–14.0%)	112 (+4.6%)
ICE	107 (–20.7%)	107 (–20.7%)	85 (–21.3%)	108 (±0.0%)
Chao1	121±31 (–12.3%)	146±66 (+5.8%)	80±16 (–19.2%)	114±37 (+15.2%)
Chao2	124±35 (–14.5%)	131±43 (–9.7%)	87±22 (–14.7%)	110±31 (+7.8%)
MMMeans	117 (–4.9%)	124 (+0.8%)	99 (–6.6%)	118 (+11.3%)

Per cent values (in parentheses) denote changes relative to the respective estimator for the entire data set (see Table 1)

(*ACE, ICE, Chao1, Chao2, MMMeans*: Colwell, 1997 and above) on the partitioned subsets of data (Table 5).

When compared to the estimator values calculated for the entire data sets (Table 1), three patterns emerge. (1) For the first four models of extrapolation (*ACE* to *Chao2*, which are based on 'rare' species in the samples) most figures as estimated from the partitioned data sets are smaller than those for the entire data set (but extrapolations for SM2 show the reverse trend). (2) Estimates based on these four algorithms tend to show quite large deviations (11 out of 16 cases differ by about 10 to 20%, SM2 again provides the only exception) from the species richness calculated for the entire data set. (3) In contrast, extrapolations according to the Michaelis-Menten model differ by less than 10% from the 'complete' estimate.

Discussion

Applicability of quantitative diversity measurers to catches at baits. Within one season of regular baiting we sampled 3015 noctuid moths representing 119 species at two study sites. This large material allowed us to test the suitability of a variety of models and methods employed in biodiversity research. For both sites the rank-abundance plots revealed the usual pattern of natural communities, which are made up by only a few very frequent species, while most species are 'rare'. Such a structure is typical for moth communities sampled by light-trapping (Kempton & Taylor, 1974; Taylor *et al.*, 1976). Our baiting data showed an excellent fit to the frequency distributions as predicted by the log-series model, which has mostly been applied thus far to light-trap data. This close correspondence is a clear indication that (a) with regular baiting a noctuid guild (namely those which feed on carbohydrate resources other than flowers) can be sampled adequately and (b) that Williams' α, as an easily computed measure of diversity, can be used to characterize such a community. Two great advantages of Williams' α are (a) that it is largely independent of sample size (so long as samples are adequately large, preferably > 100 individuals) and (b) that it condenses information of species presence and abundance into one figure (with confidence limits), thus facilitating further comparisons (see Southwood, 1978; Wolda, 1981; Hayek & Buzas, 1997).

The second type of diversity assessment, Hurlbert's rarefaction method, also performed well on our data set. Hurlbert (1971) strongly opposed the use of any 'diversity indices' and developed his alternative probabilistic parameter-free concept for assessing and comparing species richness as a function of recording intensity. With the advent of computer facilities to perform the complex calculations, these rarefaction methods are now widely used in community ecology and conservation biology (e.g. Achtziger *et al.*, 1992; Hayek & Buzas, 1997). When applied to our data set, the Hurlbert approach always led to the same conclusions about diversity as the calculation of Williams' α (see below).

Comparability of different bait mixtures and exposition techniques. Above, we have shown that quantitative analytical

Table 6. Values of Williams' α from selected studies on Noctuidae diversity (where applicable, α values were computed separately for each studied site and season)

Country	Habitat, duration of study	Source	Collection method	Diversity (Williams' α)
W Malaysia: Pahang	tropical secondary forest, 1979–1980	Barlow & Woiwod, 1989	light	104.4
E Malaysia: Sarawak	various rain forest types, 1977–1978	Holloway, 1984	light	251.2
E Malaysia: Sabah	rain forests and plantations, 1987–1989	Holloway *et al.*, 1992	light	44–170
Canada: New Brunswick	coniferous forest (within canopy), 1990 (2 mon)	Thomas & Thomas, 1994	light	24.8
Canada: New Brunswick	coniferous forest (above canopy), 1990 (2 mon)	Thomas, 1996	light	29.8
USA: W Virginia	deciduous broadleaved forest, 1984–1986	Butler & Kondo, 1991	light	30.0–38.9
S Norway:	mixed forest and cultivated landscape, 1969–1971	Bakke, 1974	light	23.8–27.7
Sweden: Skane	suburb gardens, 1968–1969	Persson, 1971	light	23.3–23.5
Germany: Rhine province	various forest types, 1985–1986	Mörtter, 1988	light	11.0–25.1
Germany: S Bavaria	mixed cultural landscape, 1987–1988	Hausmann, 1990	light	19.9–30.0
Germany: NE Bavaria	mixed cultural landscape, 1997 (6.5 mon)	this study	bait	23–24
Russia: Kola Peninsula	degraded boreal forests, 1991–1993 (total 3.5 mon)	Kozlov *et al.*, 1996	bait	2.3–3.5

methods may be applied to noctuid samples from baits. However, most studies known to us about bait-trapping of moths in temperate regions are restricted to qualitative lists of species. Moreover, even proponents of baiting for faunistic studies usually emphasize that too many factors affect the success of baiting to allow for quantitative elaboration of such data (e.g. Steiner & Nikusch, 1994). We have empirically tested two sets of factors (i.e. methodological and climatic) which are commonly proposed as objections against more sophisticated analyses of baiting data.

A prime requirement to allow for comparisons between different studies (and this is the basic reason why quantitative methods have been developed at all) is that, if drawn from the same community, samples obtained with different methods must yield congruent results. Specifically, this means that neither bait mixture nor exposition method should affect the assessment of a given community. In fact, we observed that the two bait mixtures differed drastically with regard to numbers of species and individuals attracted, and bait presentation also had a profound effect on baiting efficiency. Thus, at a first glance these results seem to support the pessimistic attitude towards baiting as a quantitative method.

Calculation of Williams' α (Table 2) and application of Hurlbert's rarefaction method (fig. 4), however, demonstrated that, with regard to diversity, differences between samples were all minimal and not significant. Hence, the two bait mixtures and three presentation techniques only differed in the number of moths attracted, but all these methods drew samples of equal diversity pattern from the same natural community. Further support for this conclusion comes from the estimates of similarity between samples caught with the different methods or baits. Values of all similarity indices tested were high (mostly $\geq$70%). Only the sample of noctuids attracted to baits on tree trunks at a height of 50 cm differed more, but at these baits so few moths were caught that this result should not be overrated. Still, the Dice index (the most suitable for such impoverished samples) indicates a similarity of 83% to the sample caught higher up at tree trunks. Finally, we obtained no evidence that any of the commoner moth species could be exclusively observed at one bait mixture or with one exposition method. Hence, apparent

methodological differences are effects of sample size and emphasize the general notion that comparisons of mere numbers of recorded species are usually inadequate to assess diversity whenever sample sizes, or sampling effort, are variable (Mawdesley, 1996).

Why did bait mixtures or presentation techniques differ in absolute effectiveness? Since we have not addressed this question experimentally, we can only propose some explanatory arguments. It seems likely that the odour plume dissipating from baits suspended from a rope distributes more freely as compared to bait patches on tree trunks. From the same reasoning, baits at a height of 200 cm at tree trunks are probably easier to locate for a flying moth than those at 50 cm. Accordingly, the differences in effectiveness between the exposition techniques are likely due to the intensity and range of the olfactory cues which emanate from the food source.

The distinct preference for the sugar mixture over the banana bait is more difficult to explain. In particular in late summer and autumn, rotting fruits are important natural food sources of bait-visiting moths (Steiner & Nikusch, 1994; Steiner, 1997). Thus, one might have expected the banana bait, with its (for the human observer) more intensive smell of decaying and fermenting fruits, to be more attractive, but the opposite was true. For preparation of the two bait mixtures, equal fresh weights (500 g) of sucrose and bananas, respectively, had been used. Hence, the sugar content of the banana bait was certainly lower, and this might be one reason for the preference pattern observed. One should expect that noctuid moths, with their substantial energy consumption during warming up and active flight (Heinrich & Mommsen, 1985), would be predominantly attracted to the most profitable food source. The cues used for resource location, however, still need to be addressed with suitable experiments.

Our observation that, under otherwise equal conditions, a wine-sugar mixture was more effective than a wine-banana bait calls into question the significance of strongly smelling additives in baits. Nutrient concentration may be more influential than the presence of fruit esters (e.g. maleic acid diethyl ester) or the use of manifold "secret" mixtures as employed by older authors (Lederer, 1957; Steiner & Nikusch, 1994). In full agreement with

our results, Pinker (1970) and Nippel (1976) also observed highest attractiveness with simple red wine-sugar baits.

In sum, our methodological comparisons reveal that noctuid samples obtained by baiting can be used to characterize the diversity of a moth community even if different mixtures or presentation methods are employed. Methodology does affect sample sizes, but not estimates of community structure extracted from the samples. The better standardized both bait mixture and exposition are, the more reliable the results will be. Most importantly, our findings open up the venue to quantitative comparisons between studies at different locations or in different years. It is only required to obtain sufficiently large samples with a standardized recording technique, and with all species and individuals being noted. The objection (e.g. Steiner & Nikusch, 1994) that results of baiting surveys could *a priori* never be used for quantitative analyses is no longer tenable.

Climatic factors and the response to baits. As expected, the number of noctuid individuals and species attracted to baits was strongly affected by temperature: the warmer an evening the more moths appeared. Below 5°C very few moths were caught, and 9 out of 10 evenings when not a single noctuid showed up at the baits had mean temperatures below 7°C. This strong temperature-dependence corresponds well with the observations of Lederer (1959) at baits (the same applies to light-traps: Muirhead-Thomson, 1991).

Wind speed, in contrast, had no detectable influence, although the highest catches occurred at nights with but little wind. Wind may influence the effectiveness of light traps because it facilitates passive drift as well as migration flights (Hausmann, 1990; Muirhead-Thomson, 1991). Our data indicate that noctuid moths in search for food (the behavioural context in which they are attracted to baits) are less affected by wind, at least in the range of wind speeds recorded during our observation period (up to 4 m/s).

Rainfall occurred on 18 of 106 sampling evenings. We always noted at least some moths at the baits when it was raining. Numbers of attracted individuals were not noticeably lower on rainy nights. In July, the month with highest precipitation in 1997, for example, we caught between 12 and 57 individuals at

the baits on 6 evenings with rain, compared to 12–83 individuals on 12 nights without rain ($t_{16df} = 1.02$, $p > 0.3$). In early spring or autumn rainfall might even be advantageous for baiting, because then usually temperature does not drop as much as on cloudless nights. In any case, rainfall does not *per se* negatively affect bait-trapping success (see also Nippel, 1976).

Baiting versus attraction to artificial light sources. Today, most quantitative studies of moth communities use attraction to artificial light sources (termed "light-trapping" hereafter for convenience) as the basic method of sampling (e.g. Mörtter, 1988; Hausmann, 1990; Wolda *et al.*, 1994 for temperate regions; Robinson & Tuck, 1993, Chey *et al.*, 1997 for tropical communities). The applicability of quantitative diversity measures to light-trapping data has been extensively explored (Kempton & Taylor, 1974; Taylor *et al.*, 1976; Robinson & Tuck, 1996) and lends high credibility to results of such studies. However, as with any sampling method, light-trapping may be influenced by a large number of factors which all may bias or even heavily distort the results. Among the factors known to interfere with light-trapping efficiency are spectral composition of light stimulus, ambient temperature, light environment, lunar period and wind speed (review: Muirhead-Thompson, 1991). Most disturbingly, the physiological mechanisms underlying the attraction of moths to lights are not yet satisfactorily understood (Steiner & Nikusch, 1994). Even among closely related species the response to light sources may differ distinctly, and in any case the sampling procedure is based on an unnatural stimulus. Despite all these drawbacks, light-trapping data have empirically demonstrated their usefulness as a tool in community ecology and biodiversity research.

From the data presented in this study we conclude that bait-trapping data can be equally useful. Just as with light-trapping, a number of factors (such as ambient temperature, bait mixture, baiting technique) do affect the efficiency of recording, but the resulting samples can well be evaluated using much the same analytical techniques. There is no generally "superior" method of sampling nocturnal moths. Light sources have the advantage of attracting a larger taxonomic range of moths in usually larger numbers (thus increasing scope and decreasing time effort), but

often have the disadvantage of highly male-biased sex ratios in samples (Mörtter, 1988; Hausmann, 1990). Certain abundant species (such as in the genera *Amphipyra* or *Conistra*) are selectively under-represented at light as compared to records at baits. Bait-trapping, in contrast, utilizes a natural behavioural context and stimulus for attraction and yields more even sex ratios. In our sample the cumulative sex ratio was 1418 males to 1578 females (not all specimens were sexed; comparison against null hypothesis of even sex ratio: $\chi^2_{1df} = 8.55$, $p<0.005$), thus even indicating a significant slight surplus of females. Bait-trapping therefore has the potential of revealing certain ecological aspects of a community (e.g. patterns of abundance and dominance) more accurately, but only that fraction of moths which utilize food resources similar to the exposed baits can be monitored (mainly Noctuidae, but also many Geometridae: Süssenbach & Fiedler, in press).

How does the diversity of our baiting samples rank in comparison with published data derived mostly from light-trapping? In Table 6 we have summarized examples from studies on noctuid moths where Williams' α has been presented explicitly, or could be calculated using the published data. Our diversity figures agree surprisingly well with other data obtained from light-trapping studies at medium latitudes in northern temperate zones. Only samples from industrially degraded subarctic landscapes in northernmost Russia or dense spruce plantations in western Germany have much lower, and samples from tropical moist forests much higher diversity. The close correspondence between our baiting data and the published light-trapping studies suggest that noctuid communities at latitudes between 45° and 55°N can be generally characterized by values of Williams' α ranging from 20–40, and that baiting is equally suitable to assess such values with sufficient accuracy. Unfortunately, most faunistic surveys we have come across were not conducted in a quantitative manner, or the data have not been published in a form which would allow *post hoc* calculations of diversity statistics. Hence, a critical comparative re-appraisal of diversity figures for different moth taxa and across geographical gradients still awaits to be done.

Discrimination between communities. Biodiversity research is not only concerned with adequately measuring "richness" of

communities (α-diversity), but also with discriminating between communities (β-diversity). With regard to the former, our samples indicate that noctuid α-diversity did not differ markedly between the two sites despite their different vegetation structure. The main difference was that on the BG site we captured about twice as many moth individuals as at the SM site. It is always critical to infer abundance from quantitative samples, because practically all sampling methods, at least for mobile organisms, are biased by factors such as activity or specific differences in catchability of the animals in question. Although our data indicate that at the SM site the guild of bait-visiting noctuids was less numerous, such a result needs to be validated by independent measures of abundance (e.g. based on larval densities) which we presently do not have.

However, with regard to species composition, both sites showed strong similarity. Similarity was particularly high if only presence of species was evaluated (Sörensen and Dice index: 77–85%), while the two communities could be more clearly separated using the abundance-based Morisita and Renkonen indices (55–60%). This finding agrees with Wolda's (1981) perception that Morisita's index is particularly suitable for assessing community similarity and again underlines that baiting data for noctuid moths are well suited for studies in community ecology.

Estimating diversity and species richness. Numerous methods of expressing "diversity" have been suggested, and most of these have advantages as well as disadvantages (see Southwood, 1978; Magurran, 1988; Lande, 1996 for thoughtful discussions). Two widely used ways of measuring diversity yielded congruent results in our study, namely fitting one parametric model (Williams' α) and probabilistic estimation of species richness by controlling for sample size effects (Hurlbert's rarefaction). Both these methods are highly suitable for analysing quantitative bait-trapping data, because they effectively suppress the bias resulting from variation in sample size and sampling effort, as long as all samples used for the calculations have been assembled with the same standardized methods, are randomly drawn from the community, and are sufficiently large.

A disadvantage common to both methods is that they produce rather abstract figures. For many purposes, including conservation

biology, the "real" number of species in a community would provide a more meaningful and convincing measure. However, at least with mobile organisms, it is in principle impossible to be sure that one has ever sampled a community exhaustively (i.e. that further sampling would not add any more species to the records). The collecting effort necessary to approach real saturation increases with species richness and diversity of a community.

Extrapolation from samples to communities might provide a solution to that dilemma (Colwell & Coddington, 1994). In the present study we have tested some extrapolation methods suggested by Colwell (1997). These methods have not yet been widely used, but tests using samples of Mexican hawkmoths (León-Cortés *et al.*, 1998) as well as model data sets (Peterson & Slade, 1998) both arrive at the conclusion that a Michaelis-Menten process (termed Clench's function there) yields the most robust asymptotic estimation and that Chao's estimates likewise give robust estimates.

From our own data set, the following patterns emerge. (1) As expected, all extrapolations arrive at higher numbers than actually recorded species. Despite very intensive sampling effort at neither site have we achieved a complete inventory of the noctuid guild attractable to baits. (2) For both habitats, the estimators converge to similar figures (123–145 spp. at the BG site, 99–108 spp. at SM), which would suggest that "true" species richness lies somewhere in these intervals. (3) The estimators perform differently on the two data sets. In the larger BG sample, the randomized species accumulation after the Michaelis-Menten model produces a low estimate, while it yields a medium estimate in the smaller SM sample. This could be an effect of samples size: all else being equal, the larger the sample is, the closer the randomized hyperbolic function should be to its asymptote. (4) The Michaelis-Menten estimator changed less when sample sizes were "experimentally" halved. The four other estimators showed no uniform response when applied to rarified samples.

How realistic are the estimated species numbers? No data are available exactly for our two study sites, but from the vicinity of Bayreuth (radius about 10 km) at least 246 Noctuidae species have been recorded thus far (Wolf, 1981; Süssenbach & Fiedler

in press). According to the multi-volume monograph of the noctuid fauna of SW Germany (Ebert, 1997; Steiner, 1997; Steiner & Ebert, 1998), about 61% of all noctuid species have been observed visiting fruit baits. Applied to the north-eastern Bavarian fauna, one might therefore expect a regional pool of 150 species (61% of 246 spp.) as potentially attracted by baits. Then, estimated totals of about 100 (SM site) or 130 (BG site) bait-visiting noctuid species are not unrealistic.

The applicability and validity of species richness estimators needs to be tested against more data sets derived from a broader (taxonomical, methodological, geographical) range of studies. The newly proposed methods from Colwell (1997; i.e. *ACE* and *ICE*), in particular, require further testing. Though promising in theory and from the results on the entire data sets, their unstable performance when applied to subsamples throws doubt on their usefulness. As it stands, the Michaelis-Menten model appears to be a robust, albeit conservative method of estimating total species richness (see also León-Cortés *et al.*, 1998; Peterson & Slade, 1998).

Baiting and recording effort. A final point worth discussion is the sampling effort needed to assemble meaningful data sets. Sampling effort is usually a cost factor (time and manpower needed to conduct the sampling, but also for mounting, sorting, and identification). Hence it seems advisable to limit the sampling effort and sample sizes so as to optimize the relationship between costs (of labour and materials) and benefits (reliability of results and conclusions). For light-trapping surveys, such strategies have already been proposed and tested (Thomas & Thomas, 1994).

We have used two approaches to assess the effect of reduced sampling effort. First, we compared the data subsets which were accumulated during either the first, or second, sampling evening of each week. Although subsamples covered only 70–80% of the species as compared to the total samples, estimates of α-diversity were not affected significantly. Subsamples were also very similar to each other in species composition and abundance. However, most estimates of true species richness tended to decrease (and confidence limits to increase) for subsamples. Thus, reducing sampling effort to one evening per site and per week did not change conclusions about α- and β-diversity, but certainly would

be less sufficient for studies aimed at compiling species inventories or estimating "true" richness.

Rarefaction methods provide a second approach to study effects of sampling effort. The Hurlbert curves show that with 500 moths sampled per site about 60–80 species will be covered, corresponding to 25 sampling evenings as revealed by Shinozaki rarefaction. The Shinozaki model assumes that with each sampling unit all species have the same likelihood of being captured. Given the strong climatic seasonality at the study sites, and the profound variation between evenings in the number of moths attracted, this assumption is oversimplistic. If sampling is limited to weather conditions where larger numbers of moths can be expected (i.e. on evenings with >7°C mean temperature, and concentrating the sampling in summer and autumn, where abundance and diversity of moths at the baits was higher than in spring: Süssenbach & Fiedler in press), then as few as 10–15 sampling nights per site and season should reveal much of the community patterns, but at a cost with regard to species coverage. As a methodological standard, a simple saturated red wine-sugar bait mixture exposed on suspended pieces of cloth at a height of 2 m above ground should be sufficient for such purposes.

Sampling methods should always be selected according to the aim of a study. As we have shown above, baiting noctuids in a standardized manner can easily reveal sufficient information to characterize the noctuid community, its diversity and principal abundance structure. Reliable results can be expected even with much reduced sampling effort. When species inventories are the objective (which from statistical reasons alone will almost never be "complete"), light-trapping (with its broader taxonomic coverage) or a combination of recording methods may be chosen as more appropriate. However, for many typical questions of community ecology and biodiversity research, including conservation biology, it is no longer justified to disregard baiting as a potentially powerful tool.

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A new crambid moth species from the north-eastern part of Turkey (Crambidae: Crambinae)

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Summary. *Metaeuchromius yusufeliensis* **sp. n.**, is described from the north-eastern part of Turkey. Figures of the moth, the male and female genitalia and features of the abdomen are presented.

Zusammenfassung. *Metaeuchromius yusufeliensis* **sp. n.**, wird aus der nordöstlichen Türkei beschrieben. Abbildungen des Falters, der Genitalien sowie von Merkmalen des Abdomens werden gegeben.

Résumé. *Metaeuchromius yusufeliensis* **sp. n.** est décrite du nord-est de la Turquie. L'adulte, les genitalia mâle et femelle, ainsi que les caractères de l'abdomen sont illustrés.

Key words: Crambidae, *Metaeuchromius*, new species, Turkey.

Metaeuchromius yusufeliensis sp. n.

Holotype ♂ with labels: "NE-Turkey Prov. Artvin Kaçkar Mts.: Yusufeli, 40°50′N 41°31′E, 650 m, M. VII.1995, leg. A. Kallies, ad lumen" and "Holotypus ♂ *Metaeuchromius yusufeliensis* **sp. n.** sel. Nuss & Speidel, 1997". Deposited in Museum für Naturkunde, Berlin (Germany). Paratypes 2 ♂♂, 2 ♀♀, same data, in coll. Nuss and coll. Speidel.

Description

Imago (fig. 1). Forewing length 9–10 mm; ocelli present, chaetosemata prominent; frons rounded; labial palpi long and porrect, slightly curved downwards, tuft-like scaled, three times as long as diameter of eyes; maxillary palpi brush-shaped and upright; antennae half the length of forewings, underside pubescent, upperside scaled. Ground-colour of forewings white, almost entirely covered by black scales. The typical pattern found in the other species of *Metaeuchromius* Bleszynski, 1960 and in the related genera *Euchromius* Guenée, 1845 and *Miyakea* Marumo,

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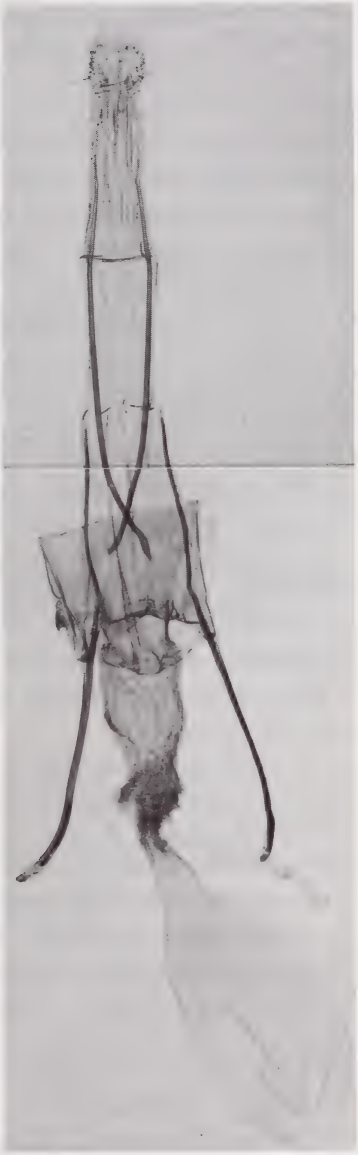

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Figs. 1–5. *Metaeuchromius yusufeliensis* **sp. n.**: 1 – holotype; 2–3 – ♂ genitalia (GU Nuss 773); 4 – ♂ abdomen, showing tympanal organ and coremata of 3rd abdominal sternite (GU Nuss 773); 5 – ♀ genitalia (GU Nuss 809).

1933 is strongly reduced. Antemedial fascia white, distally edged by ochreous scales in the central part of the wing; discocellular stigma spot-like, black, surrounded by a white ring; postmedial fascia white, sparsely covered by ochreous scales adjacent to the medial area; six ochreous patches at the external side of the postmedial fascia; termen black with six small white spots with the ochreous patches lying in the interspaces; first row of fringes shiny grey, second one chequered creamy white and brown. Male retinaculum with hamus. Hindwings uniformly pale brown, first row of fringes chequered creamy-white and pale-brown.

Abdomen (fig. 4). Tympanal organ with praecinctorium, ramus tympani interrupted mid-ventrally, venulae secundae short, processus tympani reduced. Male with coremata inserted craniolaterally on 3rd abdominal sternite.

Male genitalia (figs. 2, 3). Uncus narrow, with single setae. Gnathos strongly sclerotized, clearly broader than uncus, duckbill shaped, distally with tiny thorns; juxta axe-blade shaped; two swellings in the diaphragma situated laterally to the juxta are covered with five larger and some smaller thorns; vinculum large, v-shaped, with comparatively small saccus; costal margin of valvae with small distal thorn; aedeagus with 4 slender, slightly curved cornuti.

Female genitalia (fig. 5). Corpus bursae ovoid, membraneous, without signum; ductus bursae short, wrinkled, posteriorly to the insertion of the ductus seminalis a wrinkled knot, antrum and ostium membraneous without any sclerotisations; ovipositor and apophyses extremely long. Spermatophores globular.

Differential diagnosis. Forewings predominantly scaled black with two contrasting white fasciae strongly reminiscent of some Scopariinae. Labial palpi, however, three times as long as diameter of eyes, which is a typical character for most crambines. The species is characterised by its dark coloration.

Biology. Unknown.

Derivatio nominis. The species is named after its type locality, Yusufeli in Asia minor.

Relationships

Schouten (1997) revised the crambine genus *Metaeuchromius* Bleszynski, 1960 and substantiated the monophyly of the genus

by the presence of male scent organs situated on the 3rd sternite. This apomorphy is shared by *M. yusufeliensis* **sp. n.** The species is very similar to *M. circe* Bleszynski, 1965 from East and Central China (cf. Schouten, 1997) according to the structure of the genitalia. *M. yusufeliensis* **sp. n.** differs in the male genitalia by the roundish, swollen processus basalis and the weakly developed cornuti.

Acknowledgements

We thank our friend Axel Kallies (Berlin, Germany) for the kind gift of the material and Barry Goater (Chandlers Ford, U.K.) for correcting our English typescript. Useful comments were also received from Rob Schouten ('s-Gravenhage, The Netherlands) and Yuri Nekrutenko (Kiev, Ukraine).

Reference

Schouten, R., 1997. Revision of the genus *Metaeuchromius* Bleszynski (Lepidoptera: Pyralidae: Crambinae). — *Tijdschr.Ent.* **140**: 111–127.

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Book review • Buchbesprechung • Analyse

Hardy, Peter B.: Butterflies of Greater Manchester.
20.9 × 14.8 cm, [4] + 127 pp., 16 black-and-white habitat photographs, 15 colour photographs printed inside front and rear covers, 170 figs. [read: maps], paperback. Published by PGL Enterprises, Sale, Cheshire, 1998. ISBN 0–9532374–0–0. To be ordered from: PGL Enterprises, 10 Dudley Road, GB-Sale, Cheshire M33 7BB, United Kingdom. Price: £ 9,– excl. postage.

Urban landscapes are frequently dismissed as wastelands for wildlife. The present atlas of the butterflies of Greater Manchester clearly demonstrates that such a picture is far from true. While surrounding rural areas become quickly impoverished as a result of modern agricultural practice there are, on the other hand, sites throughout Manchester with a butterfly diversity as rich as that of rural areas beyond its boundary.

The Introduction deals with survey methods, Manchester environments, species richness and distribution, distribution changes and conservation. Then follows a chapter on species accounts proper: for each species, short paragraphs deal resp. with habitats, host plants, broods, distribution and behaviour. A table lists the species recorded in the 7 × 5 km zone, indicating the number of 100 m squares in which each species has been recorded in 1994–1997; a next one lists the nectar sources noted during 1996 and 1997 with both the species number as well as the average number of specimens per day, while a third one lists the usage of nectar sources by each single butterfly species. Then follows a list of references (50 entries). The remainder (more than half) of this work is devoted to the various maps.

This book is unique in the way maps at different scales are presented. Distribution maps are shown for each of the 27 butterflies and 2 burnet moths, either resident or not, that have been reported from 1980 on in the area considered, using the standard "tetrad" units of 2 × 2 kilometres; older records are mapped to 10 km square. Further maps of environmental features as urban cover, the road system and various open areas that are either potentially suitable or unsuitable as habitat, are presented. Mapping at smaller scales of butterfly distributions, down to 100 metre square level, is also shown, alongside with various environmental parameters. Finally, for a 3 × 2 km zone within a 7 × 5 km zone, maps for species and for their host plant habitats are presented for 100 × 100 meter squares.

The author deserves our congratulations for having presented original first hand data in a most useful and innovative way, setting a standard for future studies on wildlife in city areas. This nice little book will be of interest to naturalists, conservationists and nature lovers.

Alain Olivier

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Higgins, L. G. & Riley, N. D., 1980. A field guide to the butterflies of Britain and Europe. 4th ed. — Collins, London. 384 p., 63 pls.

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Phenology of *Charaxes jasius* (Nymphalidae: Charaxinae) in the north-east Iberian Peninsula

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Summary. Between 1994 and 1997 a population of *Charaxes jasius* (Linnaeus, 1767) was intensively studied in Catalonia (north-east Iberian Peninsula). Phenological data on adults were obtained by means of standardised transect counts and bait traps. Additional data were obtained from a number of transect routes throughout Catalonia, as part of a Butterfly Monitoring Scheme. Data on the immature stages were obtained during a systematic study of eggs and larvae. *C. jasius* is bivoltine, and the phenology is highly coincident in every season over a wide area. The first brood flies from the end of May to mid-July, and the second from the end of July to the end of September or beginning of October. In some years the second brood has a markedly bimodal emergence. Population size is much higher in the second than first brood. Hibernation occurs in the larval stage, usually between November and March, when daily mean temperatures fall below 11.5–13°C. Larvae from any instar may be found at the start of winter, but at the end of this period almost all individuals are in 3rd to 5th instars. Although *C. jasius* is potentially a continuously brooded species, these results indicate that the limitations imposed by thermal conditions set an upper limit of two broods per year in the north-east Iberian Peninsula.

Zusammenfassung. In den Jahren 1994 bis 1997 wurden an einer Population von *Charaxes jasius* (Linnaeus, 1767) in Katalonien (nordöstliche Iberische Halbinsel) Daten zur Phänologie der Imagines mittels standardisierter Transekte und Köderfallen erhoben. Zur Ergänzung dienten Beobachtungen entlang weiterer Transekte in ganz Katalonien im Rahmen eines Tagfalter-Monitoring-Schemas. Phänologische Beobachtungen der Entwicklungsstadien wurden durch systematische Suche erbracht. In Katalonien bildet *C. jasius* zwei Generationen aus, die über das Untersuchungsgebiet synchronisiert sind: von Ende Mai bis Mitte Juli, und von Ende Juli bis Ende September oder Anfang Oktober. In einigen Jahren bilden sich während der zweiten Generation zwei getrennte Populationsmaxima aus. Die zweite Generation ist stets viel individuenstärker als die erste. Die Überwinterung erfolgt als Larve, normalerweise von November bis März, wenn die mittleren Tagestemperaturen unter 11.5–13°C fallen. Zu Beginn des Winters werden Larven aller Stadien angetroffen, am Ende des Winters befinden sich fast alle Tiere im dritten bis funften Larvalstadium. Obwohl *C. jasius*

eine Art mit potentiell ununterbrochener Generationenfolge ist, begrenzen die Temperaturbedingungen im Nordosten der Iberischen Halbinsel den Lebenszyklus auf zwei Generationen pro Jahr.

Résumé. De 1994 à 1997, une population de *Charaxes jasius* (Linnaeus, 1767) de Catalogne (nord-est de la péninsule ibérique) a été étudiée intensivement. Des données sur la phénologie des adults ont été obtenues au moyen de comptes standardisés suivant des routes fixées ainsi que des trappes à appât. Un complément de données fût fourni en provenance d'un nombre de routes fixées à travers toute la Catalogne, faisant partie d'un Programme d'Inventarisation des Papillons Diurnes. Une étude systématique des œufs et des chenilles fournit des données quant à la phénologie des premiers états. *C. jasius* est bivoltine, et la phénologie est hautement synchronisée à chaque saison à travers une large région. La première génération vole de fin mai à la mi-juillet, et la deuxième de fin juillet à fin septembre ou début octobre. Certaines années, la deuxième génération montre deux périodes distinctes d'éclosion maximale. La deuxième génération est toujours nettement plus nombreuse que la première. L'hibernation a lieu à l'état larvaire, en général de novembre à mars, quand les températures moyennes journalières descendent en dessous de 11.5–13°C. Des larves à chaque état peuvent être rencontrées au début de l'hiver, mais à la fin de cette période la quasi totalité des individus appartiennent du troisième au cinquième état. Bien que, potentiellement, *C. jasius* soit une espèce à générations multiples et continuelles, ces résultats indiquent que des limites imposées par les conditions thermales réduisent le nombre de générations à deux par an dans le nord-est de la péninsule ibérique.

Key words: Nymphalidae, Charaxinae, *Charaxes jasius*, phenology, Catalonia, Iberian Peninsula.

Introduction

Charaxes jasius (Linnaeus, 1767) is a widely distributed species in the Afrotropics and a sole representative of the genus in the Mediterranean region (Larsen, 1986; Henning, 1989). The main host plants in the Mediterranean are the mulberry trees *Arbutus unedo* L. and, in the eastern part, *A. andrachne* L. (Higgins & Riley, 1980; Hesselbarth *et al.*, 1995). Other host plants have been recorded from the west and east Mediterranean (e.g. Nel, 1979; Feierabend, 1986; Larsen, 1986; Stefanescu, 1995) but these are only occasionally used.

The adult is bivoltine and has two well-defined broods, the first mainly in June–July and the second in August–September. A partial third brood may occasionally exist, as recorded from the south of the Iberian Peninsula during favourable winters (Verdugo, 1984). The eggs are laid individually on the upper surface of mulberry tree leaves and, depending on temperature, hatch within 8–15 days. They are readily located by their bright

yellow colour and large size (ranging from 1.5 to 2 mm). The larvae, which pass through five instars, are hardly mobile and remain chiefly on the upper surface of the resting leaf, where they spin a silk mat shortly after hatching. In many cases this resting leaf is conserved throughout development. In the last instar, the larvae usually abandon the host plant to pupate in the nearby vegetation. The duration of larval development significantly varies between the first and second brood. Larvae from the first adult brood complete growth in some two months whereas those from the second adult brood take about eight months.

C. jasius has been the subject of previous studies both on morphology and distribution (Agenjo, 1967; Verdugo, 1984; Jugan, 1998), and biology (Castro, 1949; Jauffret & Pujol, 1961; Loritz, 1963; Verdugo, 1984; Sanetra & Peuker, 1993; Hesselbarth *et al.*, 1995). This research, however, is based mainly on data from laboratory breeding but not on systematic field studies covering a long period of time. The present contribution aims at filling this gap and, using data from several populations from the north-east Iberian Peninsula monitored over the last four years, gives precise information on the phenology of the species. The adult flight period and the relative abundance of both annual broods are quantified, and data on larval development in the wild are provided.

Material and methods

Most of the data used in this study were collected at the locality of Fitor (UTM 31TEG04, altitude 200 m), in Catalonia (north-east Iberian Peninsula), between 1994 and 1997 (fig. 1). This site is located in the north of the Gavarres mountain range with a maximum altitude of 535 m. The climate is typically Mediterranean, with maximum rainfall in autumn and spring and summer drought. Temperatures are high in summer and mild in winter (Table 1). The area is siliceous in nature and dominated by Cork Oak (*Quercus suber* L.) with areas of Aleppo Pine (*Pinus halepensis* Mill.) and Stone Pine (*Pinus pinea* L.). The mulberry tree is extremely abundant and constitutes one of the most characteristic plants of the range vegetation (Domínguez *et al.*, 1992). This allows Fitor, together with the rest of the Gavarres,

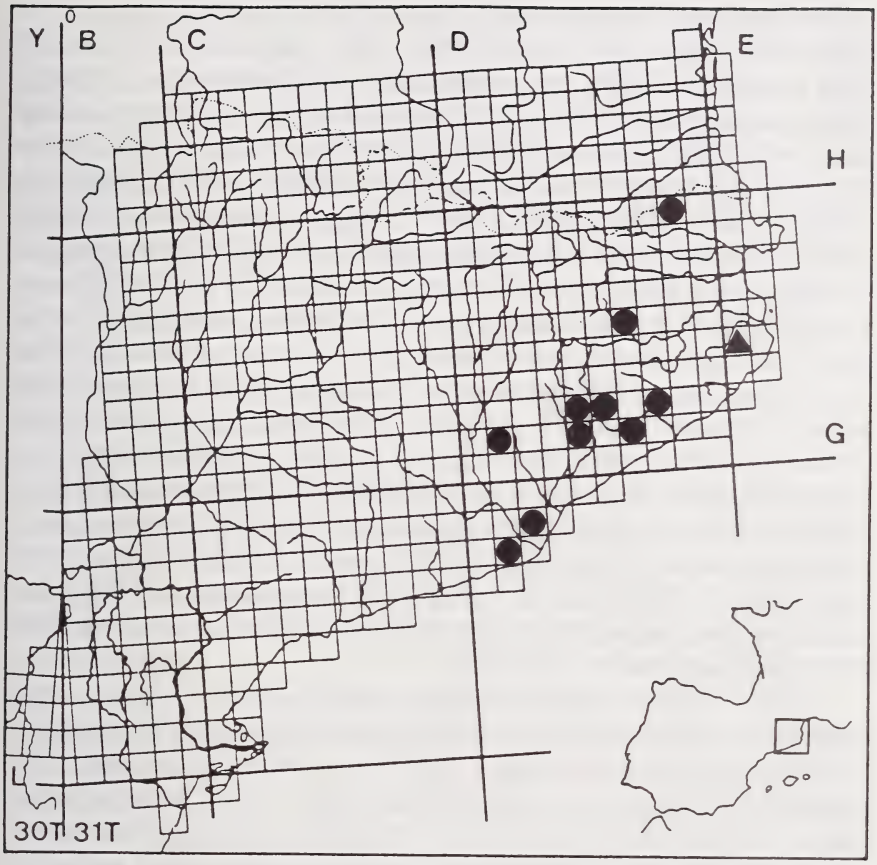


Fig. 1. Location of Fitor (▲) and rest of the BMS sites (●) with breeding populations of *Charaxes jasius*.

to support one of the largest populations of *C. jasius* in Catalonia and possibly in the Iberian Peninsula.

Phenological data both on imagoes and immature stages were obtained at this locality. Monthly mean daily maximum and minimum temperatures and rainfall for the period 1993–1997 were recorded at La Bisbal meteorological station, located at an elevation of 39 m, approx. 6 km from Fitor (Table 1).

Two different methods were used to study the imagoes: species abundance estimates from fixed transect counts and individual captures from bait traps. Transect counts followed the standard

British Butterfly Monitoring Scheme (BMS) methodology (Pollard, 1977; Pollard & Yates, 1993). The transects were walked once a week and only those butterflies seen within 5 m in front of the recorder were counted. At the end of the season, an annual index of abundance was calculated for each brood as the sum of the weekly counts, including a few missing values estimated as the mean of the preceding and succeeding counts (see Pollard, 1977, for more details). Sampling began on March 1st and ended on September 26th, thus comprising a total of 30 weeks. Because some individuals were still on the wing during October in most years, standardised counts were also conducted during that month, but data were not used in the calculations of the annual index to allow direct comparison with data from the other transects (see below). Nevertheless, numbers were usually very low in October and hence the exclusion of these counts had a minor effect in the resulting annual index. Recording was always restricted between 9:00 and 14:00 Spanish Summer Time (7:00 and 12:00 GMT). When the temperature drops below 15°C, the transects were passed through only if sunshine occurred on 75% of transect sections.

Additional data on the seasonal abundance of *C. jasius* were obtained from a number of fixed transect routes throughout Catalonia (north-east Spain) (fig. 1), as part of the Butterfly Monitoring Scheme conducted there since 1994 (Stefanescu, in press). The number of transects with breeding populations of *C. jasius* increased during the four years of the study, from an initial total of 5 in 1994 to 12 in 1997. A collated index of abundance for each brood was calculated from the transect data of the BMS sites (excluding Fitor).

The weighted mean date of the counts (MD), together with the standard deviation about this date (SD), were calculated for each brood and for every year in Fitor and at the rest of the sites, as described by Brakefield (1987) and Pollard (1991). Both measures represent estimates of the mean date and degree of synchronisation of the adult flight period. As in Pollard (1991), the recording weeks were used as the unit of time instead of the day of counts.

The data collected at Fitor with the aid of bait traps for a parallel study on adult behaviour were also used to analyse

phenology at this site. *C. jasius* adults never visit flowers but do, on the other hand, feed avidly on rotting fruit (especially figs), tree sap and animal excrements. This behaviour means they are susceptible to capture in bait traps, as is also the case with other *Charaxes* species (Rydon, 1964; Henning, 1989; Sourakov & Emmel, 1995). During the flight period of the two 1996 and 1997 broods a total of eight Blendon traps (Platt, 1969; Austin & Riley, 1995) were installed along the transect route. The traps were installed 7–12 times during the flight period of each brood. Ripe banana with a trace of anise was used as bait, a combination which proved to be strongly attractive to this species. Traps were installed from 10:00 to 20:00, and the catch has been taken out every hour (except between 13:00 and 17:00 h when the traps were emptied every two hours due to the high number of individuals captured). For each individual sex, in 1997, wing wear using an arbitrary scale ranging from 1 to 5 (1 – mint; 2 – fine but some scales lost; 3 – slight wing damage; 4 – notable wing damage; 5 – strong wing damage) was recorded. Ageing was estimated for either sex by regressing wing wear on date from the beginning to the end of the sampling period and differences between sexes were assessed using covariance analysis.

Data on the immature stages were obtained from the systematic study of eggs and larvae at Fitor, for the period 1996–1997. A series of fixed routes were established in zones where the highest oviposition activity had been observed and were walked every 2–7 days from spring to autumn and approximately every 15 days in winter. The eggs and larvae found were marked with numbered plastic tags situated at the base of the leaf stalk. At each visit the larval instar was noted (from I to V). The low mobility of the larvae made periodical monitoring easy, and losses occurring between samples were attributed to death due to predation or other causes. For each sample, a value representing the mean stage of immatures (MSI) was calculated according to the following scale: 0 – egg; 1–5 – larval instars I – V; 6 – pupa.

Results

At Fitor (as in the other studied localities) *C. jasius* adults have a clearly bivoltine phenology. The flight curves at Fitor for the period 1994–1997 are shown on figure 2. Although important

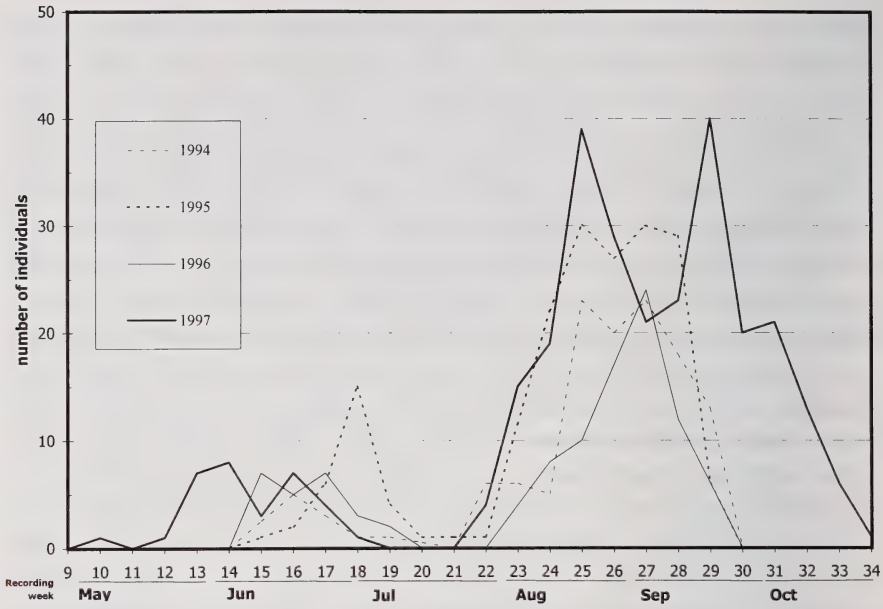
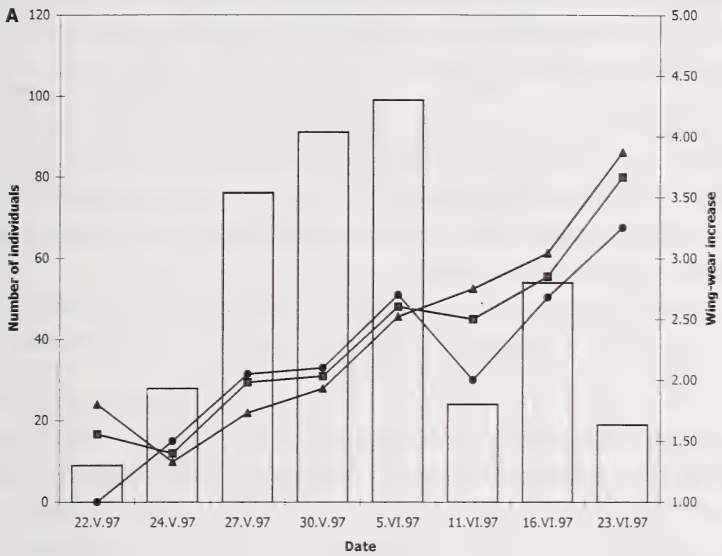


Fig. 2. Seasonal abundance of *Charaxes jasius* adults in 1994–1997 at Fitor site, as recorded by weekly transect counts.

abundance variations exist between years (as detected by changes in the annual index for each brood — see Table 2), the two broods are well separated in time. The first brood flies from the end of May to mid July (weeks 12 to 20), while the second is on the wing from the end of July to the end of September and even October (weeks 22 to 34). Occasionally, the second brood has a bimodal emergence, as can be seen from the flight curve for 1997. This bimodality is reflected perfectly by the data obtained using the bait traps (see below). The apparent bimodality of the first brood of 1997 is in reality an artefact of sampling, due to unfavourable weather conditions (very cloudy and low temperatures) affecting week 15 counts.

In all years the number of the second brood individuals was much higher than that of the first (fig. 2). On average the first brood represented 14.9% of individuals counted throughout the season (range: 10.2–22.9%; Table 2). The relation between the two broods is very similar when data from the rest of the BMS (mean 14.7%; range: 7.5–18.3%) are considered.



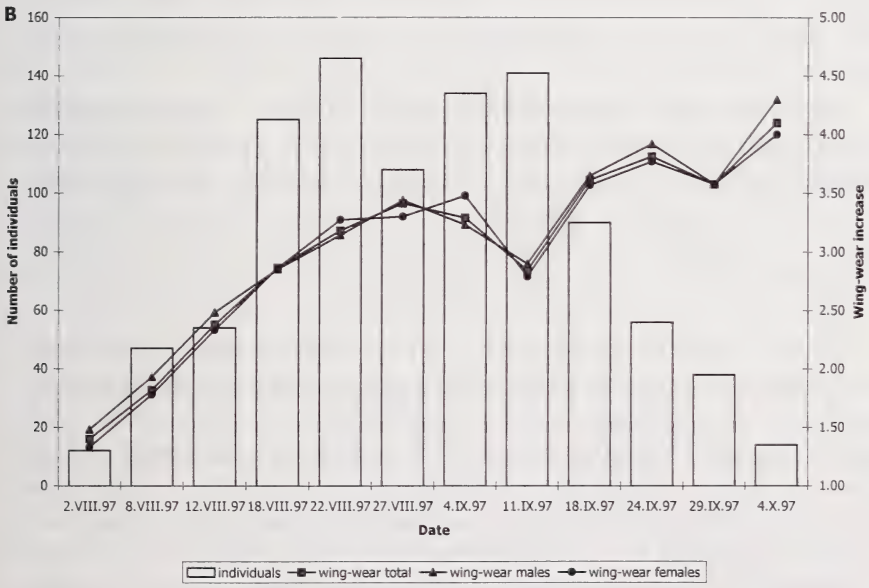


Fig. 3. Ageing of population as detected by wing wear increase from the beginning to the end of sampling in first brood 1997 (A) and second brood 1997 (B). Numbers of butterflies (histograms) are captures in bait traps.

If the results from Fitor are compared to the rest of the BMS network, a remarkable coincidence in flight periods during the four years is observed (Table 2). In only one of the eight broods studied (the first in 1995) a significant difference was observed (t-test, $p < 0.01$) between the MD at Fitor and the rest of the sites. Logically, the great similarity between the Fitor values and those from the BMS resulted in a strong coincidence in the time separating the two annual broods (dif MDs) in a given season and all over the studied area.

Throughout the four years of the study, MD variability was greater in the first brood than in the second. In the whole BMS network the first brood MD oscillated between 14.16 (1997) and 16.68 (1995), that is a difference of two and a half weeks in the flight period maximum. In contrast, the second brood MD varied in little more than half a week from 25.73 (1994) to 26.36 (1996). It should be noted, however, that the MD of the 1997 second brood would be slightly increased if data for counts during October were included. In that year the flight period of the second brood was considerably extended not only at Fitor (fig. 2) but at many localities, where a bimodal emergence pattern was also observed.

With reference to the SD, values are higher for the second than the first brood (Levene test, $p < 0.01$ in the four years tested), indicating that the first brood emergence period is more compact than the second. This is reflected perfectly in figure 2, where it can be seen that the first brood flight period at Fitor oscillates between 5–7 weeks, while for the second this is 7–13 weeks.

Data obtained through the use of bait traps confirm and complement the above results. The number of individuals captured with this methodology (843 in 1996, 1365 in 1997; Table 3) is much higher than the number of individuals detected by the counts, so the phenological data are more reliable. Even so a great coincidence in the period in which population maxima occur can be observed between the two methodologies (cf. figs. 2 and 3, Table 3). There are notable differences, however, with respect to proportions between the first and second broods. In 1996 the first brood represented 36.1% of total captured individuals while in 1997 it was 29.3%, these values being some 1.5–2 times higher than those obtained during transect counts.

For the four sampled broods the sex ratio can be taken as 1:1 (χ^2–test, $p = 0.11$). However, a predominance of females in the first brood of 1996 ($p < 0.05$) and of males in the second of 1997 ($p < 0.0001$) was found.

Figure 3 shows population ageing for the two 1997 broods. In both cases, wing wear increased with time (first brood: $y = 0.06x + 1.44$, $r = 0.964$, $p < 0.001$; second brood: $y = 0.03x + 1.95$, $r = 0.881$, $p < 0.001$; where y is wing-wear from 1 to 5, and x are the days from the beginning of the first sample). The regression equation slopes of males and females did not differ significantly in either case (ANCOVA, $F_{(1,12)} = 1.326$, $p = 0.27$ and $F_{(1,20)} = 0.009$, $p = 0.93$, respectively). On the other hand, the regression equation slopes pooled for both sexes differed significantly between the first and second brood (ANCOVA, $F_{(1,16)} = 5.326$, $p = 0.035$), suggesting that first brood adults become worn more quickly.

The existence of a bimodal emergence in the second brood of 1997 (fig. 2) is well documented by the bait traps. So, on 4th and 11th September there was a noticeable increase in the number of captures after the decrease that occurred during the last week of August (Table 3). This decrease was not the result of poor weather as all sampling in the second brood was done on hot and sunny days. Moreover, newly emerged specimens appeared in the population towards the second half of the flight period as shown by a noticeable decrease of wing wear (fig. 3). The short time separating the two peaks of abundance (four weeks compared with an average of dif MDs of 10.21 weeks in the period 1994–1997, Table 2) means that the existence of a third brood can be rejected.

Data from the monitoring of immature stages is presented in Table 4. Development of the individuals which give the second brood occurs largely during the second fortnight of June, July and early August. Important differences in development time were observed during the two years of study. Larvae grew faster in 1996 than in 1997, probably because of the higher summer temperatures of 1996 (overall mean temperature of June–July 22.69 and 21.65°C, respectively).

Hibernation occurs in the larval stage. Eggs laid by second brood adults in September and October hatch in two weeks and

Table 1. Monthly mean daily maximum, minimum and overall mean temperatures and rainfall recorded in La Bisbal meteorological station (31TEG04, 39 m) for the period 1993–1997

1993–97	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mean maximum (°C)	14.17	15.25	18.13	19.86	23.77	26.83	30.43	30.23	25.31	21.85	17.14	14.40	21.45
Mean minimum (°C)	3.97	4.12	5.37	7.57	11.50	15.13	17.64	18.33	14.05	12.09	7.87	5.27	10.24
Overall mean (°C)	9.07	9.68	11.75	13.71	17.63	20.97	24.04	24.28	19.69	16.97	12.50	9.83	15.85
Rainfall (mm)	62.72	39.72	39.04	48.30	34.88	61.76	14.82	59.44	84.44	157.94	86.72	97.20	786.98

the larvae continue growing while temperatures permit. Although larvae in any instar may be found at the inception of winter, at the end of this period almost all individuals are at the third and fourth instars (Table 4). In 1996/1997, larval growth stopped between November and February and was resumed in March. On the other hand, in 1997/1998 the MSI increased continuously, though slowly, all over the winter. Moreover, in 1997/1998 larval populations took about a month longer to reach a MSI value higher than 3.00 and, while 3.5 was reached in the first winter at the end of October, this score was just attained two months later the following season (Table 4).

Discussion

C. jasius has a typically bivoltine phenology in the NE Iberian Peninsula, with a first brood flight period in June and early July and a second in August and September. The second brood is

Table 2. Comparison between data obtained in transect counts at Fitor and the rest of the BMS sites. In brackets, number of sites with breeding populations of *Charaxes jasius*, excluding Fitor ; AI – annual index of abundance of first (1) and second (2) broods ; MD – mean date of the counts of each brood ; SD – standard deviation about this date ; dif MDs – difference between MD of the first and second broods ; t – t-test values to test for differences in MD between Fitor and the rest of BMS sites for the first (t_1) and second (t_2) broods (significance at : * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$)

	AI_1	AI_2	MD_1	SD_1	MD_2	SD_2	dif MDs	t_1	t_2
1994									
BMS sites (n=5)	6	74	16.0	1.41	25.7	1.80	9.7	–0.837	–1.725
Fitor	13	114	16.6	1.36	26.2	1.88	9.6		
1995									
BMS sites (n=8)	22	154	16.7	1.67	25.8	2.18	9.1	–2.852 ***	–0.694
Fitor	30	158.5	17.9	1.17	25.9	1.72	8.1		
1996									
BMS sites (n=11)	28	125	16.5	1.87	26.4	1.94	9.9	–0.081	0.0421
Fitor	24	81	16.5	1.29	26.4	1.56	9.8		
1997									
BMS sites (n=12)	50	264	14.2	1.66	26.3	2.08	12.1	–1.2	–1.73
Fitor	32	210	14.6	1.74	26.6	2.22	12.0		
Average 1994–1997									
BMS sites	26.5	154.2	15.8	1.65	26.0	2.00	10.2		
Fitor	24.8	140.9	16.4	1.39	26.3	1.84	9.9		

Table 3. Capture data of *Charaxes jasius* with bait traps at Fitor in 1996–1997. Columns indicate number of single captures of males and females, number of individuals recaptured and number of unmarked individuals. Sex ratios (see text) are based on single captures of males and females

first generation									
samples	1996	BMS wk	Total	male	female	recapt.	unmark.	% m	% f
1	11.VI.96	15	13	-	-		13	-	-
2	13.VI.96	15	31	-	-		31	-	-
3	15.VI.96	16	108	27	44	19	18	0.38	0.62
4	19.VI.96	16	90	26	34	18	12	0.43	0.57
5	24.VI.96	17	35	8	11	13	3	0.42	0.58
6	1.VII.96	18	19	5	5	9	0	0.50	0.50
7	11.VII.96	19	5	1	3	1	0	0.25	0.75
	Total		301	67	97	60	77	0.41	0.59

first generation									
samples	1997	BMS wk	Total	male	female	recapt.	unmark.	% m	% f
1	22.V.97	12	9	6	3	0	0	0.67	0.33
2	24.V.97	13	28	5	14	1	8	0.26	0.74
3	27.V.97	13	76	23	24	12	17	0.49	0.51
4	30.V.97	13	91	25	27	6	33	0.48	0.52
5	5.VI.97	14	99	28	43	14	14	0.39	0.61
6	11.VI.97	15	24	11	2	3	8	0.85	0.15
7	16.VI.97	16	54	18	16	5	15	0.53	0.47
8	23.VI.97	17	19	6	7	3	3	0.46	0.54
	Total		400	122	136	44	98	0.47	0.53

first generation									
samples	1996/97	BMS wk	Total	male	female	recapt.	unmark.	% m	% f
			701	189	233	104	175	0.45	0.55

second generation									
samples	1996	BMS wk	Total	male	female	recapt.	unmark.	% m	% f
1	10.VIII.96	24	7	5	2	0	0	0.71	0.29
2	17.VIII.96	25	29	17	7	2	3	0.71	0.29
3	21.VIII.96	25	104	39	38	12	15	0.51	0.49
4	26.VIII.96	26	125	48	60	10	7	0.44	0.56
5	2.IX.96	27	131	47	52	12	20	0.47	0.53
6	10.IX.96	28	86	33	32	10	11	0.51	0.49
7	16.IX.96	29	43	17	15	7	4	0.53	0.47
8	28.IX.96	31	17	5	8	2	2	0.38	0.62
	Total		542	211	214	55	62	0.50	0.50
Total 1996	843								
recaptured	115								
unmarked	139								

second generation									
samples	1997	BMS wk	Total	male	female	recapt.	unmark.	% m	% f
1	2.VIII.97	23	12	6	3	1	2	0.67	0.33
2	8.VIII.97	23	47	22	12	0	13	0.65	0.35
3	12.VIII.97	24	54	27	18	3	6	0.60	0.40
4	18.VIII.97	25	125	58	47	8	12	0.55	0.45
5	22.VIII.97	25	146	65	53	11	17	0.55	0.45
6	27.VIII.97	26	108	38	49	12	9	0.44	0.56
7	4.IX.97	27	134	87	16	5	26	0.84	0.16
8	11.IX.97	28	141	64	53	10	14	0.55	0.45
9	18.IX.97	29	90	36	39	6	9	0.48	0.52
10	24.IX.97	30	56	17	23	6	10	0.42	0.57
11	29.IX.97	31	38	16	11	6	5	0.59	0.41
12	4.X.97	32	14	4	7	1	2	0.36	0.64
Total		965	440	331	69	125	0.57	0.43	
Total 1997	1365								
recaptured	113								
unmarked	223								

second generation									
samples	1996/97	BMS wk	Total	male	female	recapt.	unmark.	% m	% f
			1507	651	545	124	187	0.54	0.46
Total 1996/97	2208								
Total male	840								
Total female	778								

Table 4. Number of immatures of *Charaxes jasius* (first and second broods of 1996–1997) found in transect counts at favoured oviposition sites in Fitor. For each sample, a value representing the mean stage of immatures (MSI) and the range of stages (E – egg ; LI–LV – larval instars I–V respectively ; V ; P – pupa) is provided (see text for more details)

second generation 1996

	28.VI.96	02.VII.96	04.VII.96	09.VII.96	11.VII.96	17.VII.96	21.VII.96	25.VII.96	28.VII.96	05.VII.96
Number of individuals	16	16	25	21	25	11	13	12	8	6
MSI	0.31	0.50	0.80	1.19	1.56	2.55	3.38	4.00	4.62	5.50
Range of immature stages	E-LI	E-LII	E-LIII	E-LIII	E-LIV	LI-LV	LII-LV	LII-P	LIII-P	LIV-P

second generation 1997

	16.VI.97	22.VI.97	30.VI.97	07.VII.97	11.VII.97	15.VII.97	23.VII.97	28.VII.97	03.VIII.97
Number of individuals	27	31	24	11	7	5	6	5	4
MSI	0.37	0.74	1.08	2.36	4.14	4.00	4.67	5.40	5.75
Range of immature stages	E-LIII	E-LIV	E-LIV	E-LV	LII-LV	LII-LV	LIII-P	LIV-P	LV-P

first generation 1997

	07.IX.96	15.IX.96	25.IX.96	11.X.96	17.X.96	25.X.96	05.XI.96	12.XI.96	25.XI.96	10.XII.96	23.XII.96	18.I.97	17.II.97	03.III.97	23.III.97	01.IV.97	15.IV.97
Number of individuals	40	72	97	57	47	36	32	28	24	16	14	8	6	5	4	4	4
MSI	0.42	0.69	1.45	2.68	2.87	3.47	3.53	3.64	3.54	3.44	3.43	3.50	3.67	3.80	4.50	5.00	5.75
Range of immature stages	E-LIII	E-LIII	E-LIV	E-LIV	E-LIV	LI-LV	LI-LV	LI-LV	LII-LV	LII-LIV	LII-LIV	LII-LIV	LIII-LIV	LIII-LIV	LIV-LV	LIV-P	LV-P

first generation 1998

	18.VIII.97	01.IX.97	15.IX.97	28.IX.97	10.X.97	17.X.97	01.XI.97	16.XI.97	28.XI.97	10.XII.97	28.XII.97	14.I.98	30.I.98	20.II.98	13.III.98	31.III.98	16.IV.98
Number of individuals	47	92	110	115	110	94	77	57	38	32	23	13	10	10	9	6	6
MSI	0.49	1.23	1.39	1.60	1.97	2.06	2.53	2.95	3.21	3.25	3.43	3.62	3.80	4.20	4.67	5.00	5.67
Range of immature stages	E-LII	E-LIV	E-LIV	E-LV	E-LV	E-LV	E-LV	E-LV	E-LV	LI-LV	LI-LV	LII-LV	LII-LV	LIII-LV	LIV-P	LIV-P	LV-P

always more abundant than the first, a common feature of bivoltine species at middle latitudes (Pollard, 1984) and, in the case of *C. jasius*, a direct consequence of the high mortality of the hibernating larvae (unpubl. data).

The differences found with respect to the relative abundance of the two broods when transect counts or bait trap data are considered may be attributed to two different reasons. Firstly, the number of second brood individuals is so high that the traps become saturated in the middle part of the day and population size is underestimated. Secondly, the availability of ripe fruit is far greater in August and September than in June and so the traps are more effective during the first brood.

A comparison between a very large population and several other populations monitored within the Catalonian BMS, revealed a highly coincident phenology in every season over a wide area. Thus, no significant differences were detected in the MDs (calculated from transect data) in seven out of eight broods studied. Moreover, the only significant value (first brood 1995) was probably due to an abnormally high count towards the end of the flight period in Fitor, when several individuals were concentrated on excrements along the transect route.

Even though the number of BMS stations with breeding populations of *C. jasius* increased during the four years of the study (from an initial total of five, excluding Fitor, to eleven), the MDs continued to coincide. This synchrony shows that the populations are subject to very similar climatic conditions typical of littoral and prelittoral Mediterranean ecosystems of the NE Iberian Peninsula (fig. 1). This coincidence also indicates that the standardised transect counts used in the BMS provide a very accurate description of the flight period, even though *C. jasius* is ordinarily a scarce butterfly at most sites and correspondingly counts are low.

There is no doubt that the principal conditioner in advance or delay of the flight period between different seasons is temperature and its corresponding effect on the development period of the immature stages (Scriber & Slansky, 1981). A clear example can be seen in the 1997 season, where abnormally high temperatures in March–May (15.5 *vs.* 14.08° C for the period 1993–1996) and abnormally low for the period June–July (21.65 *vs.* 22.72° C

for the period 1993–1996) were combined. The first brood advanced slightly more than two weeks with respect to the corresponding mean for 1994–1996, while the second showed the opposite trend as revealed by the highest dif MDs value recorded that year over the whole period (Table 2).

The temperature effect is particularly evident in the case of larvae resulting from the second brood. In 1996/1997 development suspended between November and February, when mean temperatures oscillated between 9.28 and 11.57°C. In contrast, though mean temperatures from December to February were lower (9.2–10.4°C) in 1997/1998, MSI values increased continuously, though slowly, during this period (Table 4). These results seem somewhat contradictory, as they suggest that the species' lower thermal threshold varies depending on the season. Nevertheless, this apparent paradox may arise, in part, from the differences in the timing of the second brood of adults coupled with the highest mortality usually experienced by eggs and young larvae (unpubl. data). As a result of the bimodality of the second brood in 1997 (fig. 2), eggs were found until late November and first instar larvae occurred until late December, that is, one month and a half later than in the previous season (Table 4). The more severe mortality acting on these young stages could lead to an increase of the MSI values during the first half of the winter, even in the case that larvae were in a complete growth arrest. The steady increase of the MSI values during January and February is more difficult to explain, but could also be a consequence of the haphazardly disappearance of older larvae due to predation and the corresponding variation in the size and structure of the samples.

It is interesting to note that an increase in summer temperatures does not always lead to a reduction of larval development time. Thus, the summer of 1994 was the hottest of the period considered but the time separating the two broods was longer than in 1995 (Table 2). Both July and August 1994 were extremely hot: mean maximum temperatures exceeded 31°C and maximum temperatures near 40°C were recorded on several days. These unusually high temperatures can affect caterpillar growth detrimentally in different ways. They may be outside the thermal optimum temperature of the species and hence increase respiratory expen-

diture (e.g. Casey, 1993), but may also affect food quality by dramatically reducing the leaf water content in periods of drought stress (e.g. Slansky, 1993 and references given), as usually happens with the mulberry tree (Castell, 1997).

These results indicate that the restrictions imposed by thermal conditions set an upper limit of two broods per year in the NE Iberian Peninsula. Mean temperatures from December to February are always less than 12.5°C along the littoral and prelittoral (Clavero *et al.*, 1996) and under such circumstances larval growth is much reduced if not completely arrested. This is the usual phenology throughout the rest of the area of distribution including the southern limit in North Africa (Tennent, 1996). Exceptionally, however, a third brood of adults may exist in the south of the Iberian Peninsula in December–January in years with an exceptionally mild winter (Verdugo, 1984). This third brood is also obtained when larvae from the second brood are reared indoors with high temperatures and natural photoperiod (pers. obs.) and, therefore, *C. jasius*, like many other *Charaxes* spp. (Owen & Chanter, 1972), is in fact a potentially continuously brooded species.

The existence of two peaks of butterfly abundance during the second brood in some years (e.g. in 1997, fig. 2), may be confounded with a multivoltine cycle with three broods. The data obtained through the bait traps in 1997 clearly indicate that this bimodal curve is real (Table 3, fig. 3) and is a consequence of a multimodal emergence and not a third brood. The same conclusion is reached for the immature stages, where monitoring never confirmed the existence of a third brood (Table 4). In contrast to other butterflies where bimodal emergence has been established (e.g. *Papilio glaucus* — Hagen & Lederhouse, 1984; *Maniola jurtina* — Goulson, 1993), in the case of *C. jasius* this does not seem to resemble an intrinsic population characteristic repeated annually. It seems more likely that this appears occasionally in response to particular environmental conditions. For example, the unusually cold temperatures recorded at the end of June 1997 could have affected eggs and larvae differentially and thus enhanced differences in the total development time between parts of the population. A similar reasoning was suggested by Dennis (1985) to explain the multimodality within broods in British *Aglais urticae*.

Further laboratory experiments under controlled temperatures would be necessary to assess not only those abiotic factors governing larval development but also the potential variation and plasticity of individual growth. Undoubtedly, this information will help to interpret correctly specific patterns found in natural populations.

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Notes on the ecology and distribution of two species of the genus *Epicopeia* in Korea and Vietnam (Epicopeiidae)

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Summary. Two species of the genus *Epicopeia* Westwood were studied in the field during entomological expeditions to Korea and Vietnam (1980–1995). *Epicopeia mencia* Moore, 1874 was recorded in northern Korea (Pyongyang env.), Palaearctic Region. *Epicopeia hainesii* Holland, 1889 was observed in northern Vietnam (Tam Dao Mts.), Oriental Region. *E. mencia* was reared successfully in the laboratory. The activity of the adults of both species in the field was observed.

Zusammenfassung. Zwei Arten der Gattung *Epicopeia* Westwood wurden auf entomologischen Expeditionen nach Korea und Vietnam (1980–1995) im Freiland studiert. *Epicopeia mencia* Moore, 1874 wurde im nördlichen Korea (Umg. Pyongyang) in der palaärktischen Region gefunden. *Epicopeia hainesii* Holland, 1889 wurde im nördlichen Vietnam (Tam Dao Mts.) in der orientalischen Region beobachtet. *E. mencia* wurde erfolgreich im Labor gezüchtet. Es wurden Beobachtungen zur Aktivität von Faltern beider Arten im Freiland gemacht.

Résumé. Deux espèces du genre *Epicopeia* Westwood ont été étudiées dans leur habitat naturel lors d'expéditions entomologiques en Corée et au Vietnam (1980–1995). *Epicopeia mencia* Moore, 1874 a été rapportée de Corée du Nord (environs de Pyongyang), en région paléarctique. *Epicopeia hainesii* Holland, 1889 a été observée dans le Nord-Vietnam (Mts. Tam Dao), en région orientale. *E. mencia* fût élevée avec succès en laboratoire. L'activité des adultes des deux espèces dans la nature fût observée.

Key words: Lepidoptera, *Epicopeia*, life cycle, rearing, Korea, Vietnam.

Epicopeiidae (Drepanoidea — Minet, 1991) is a small moth family distributed in the Oriental region and in the southeastern parts of the Palaearctic. Adults of this family mimic butterflies of the family Papilionidae, especially the genus *Atrophaneura*. There is little information on the distribution, biology and habitats of the Epicopeiidae (see Janet, 1913, Strelkov, 1932, Inoue *et al.*, 1982 and Yen *et al.*, 1995).

Epicopeia mencia Moore, 1874

This species was observed in northern Korea, Ryongak-san Hill in the Taedong-gang Basin, Pyongyang env., at an elevation of ca. 150–250 m (39°00′ N, 125°35′ E): 18.VII.1985, ♂; 27.VII–6.VIII.1990, 200–300♂♂, 3♀. This hill is covered by secondary growth, which consists predominantly of deciduous oak forest (about 200 ha). The surrounding landscape is agricultural land. For a detailed description of this locality, which is a "habitat island", see Jaroš *et al.* (1992). The adults are diurnal and heliophilous; the ♂♂ fly usually from 15:00 until sunset. Many specimens (ca. 40/hr) were observed flying above the tree canopy. The ♀♀ remain on the trees, and only 3 ♀♀ were found, two of them in copula. This species was never collected at night by light trapping.

The eggs were deposited in batches of about 20–100, usually on the upper surface of leaves of *Ulmus* spp. They are yellow, but one day before hatching the black heads of the larvae are visible. The larvae were reared in the laboratory at 25°C (23–27°C) on leaves of *Ulmus laevis* Pallas. The leaves of other *Ulmus* species (*U. minor* Miller and *U. glabra* Hudson) appeared to be equally suitable for rearing the larvae. The mean duration of the immature stages of *E. mencia* is given in Table 1. After hatching, the larvae aggregate on the upper surface of a leaf but do not feed. These 1st instar larvae are coloured yellow orange, head black. After moulting to the 2nd instar, the larvae start to feed gregariously at the margin of a leaf. 2nd instar larvae are covered with white waxy powder. From the 4th instar until pupation, larvae live individually. 2nd to 6th instar larvae are of a pale brownish colour, covered with 1–3 mm of a white waxy powder, and have a black head. The full-grown 6th instar larva is about 4–6 cm long. Larval mortality in laboratory was very low, less than 3%, apparently caused by handling. No diseases were observed. The larvae pupated in the soil in a thin silken cocoon covered with the larval waxy powder. The pupa is black, about 18–22 mm long. The pupae were kept either outdoors (average temperature about 0–2°C, decreasing to min. ca. –10°C), or in a cold room at 3–5°C. No mortality was observed during hibernation. Adults emerged usually in June–July and fed on water with honey. Mean longevity of females (n = 25) was 15–25

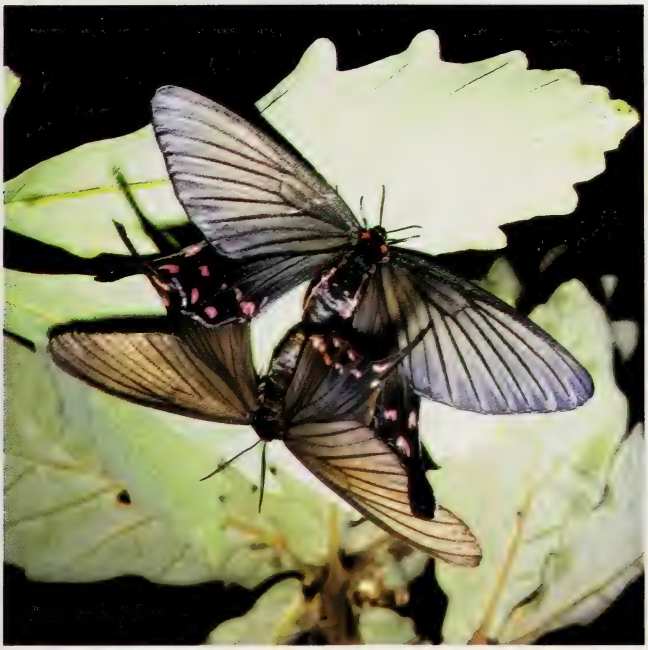

Fig. 1. *Epicopeia mencia* in copula.

Fig. 2. *Epicopeia mencia*, egg batch on *Ulmus* leaf.

Fig. 3. *Epicopeia mencia*, 3rd instar larvae; small larvae are perhaps mimics of some mealybugs (Pseudococcidae).

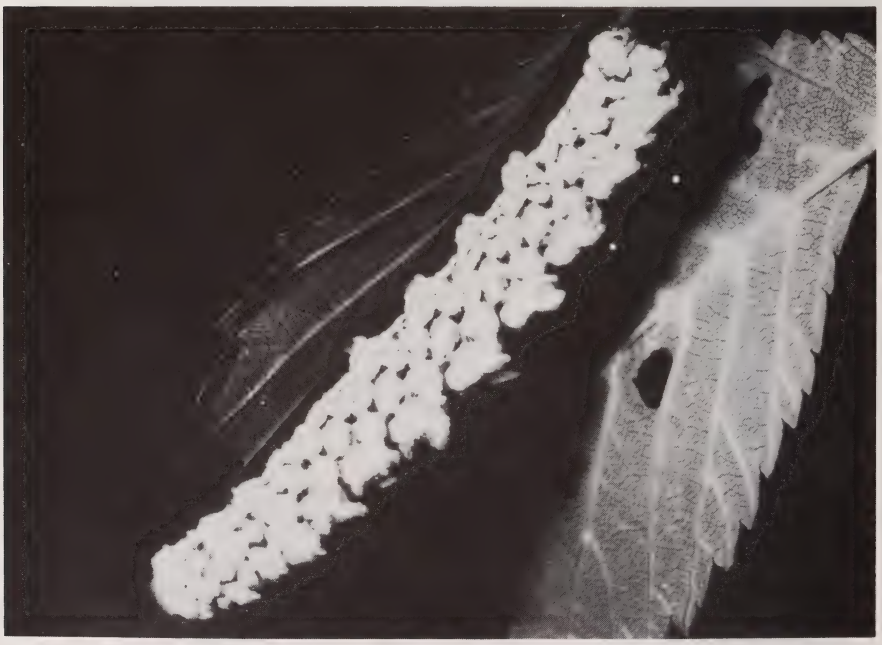

Fig. 4. *Epicopeia mencia*, 6th instar larva.

Fig. 5. Habitat of *Epicopeia mencia* in northern Korea (Ryongak-san Hill).

Table 1. The mean duration (days) of the immature stages of *E. mencia* reared *ex ovo* in captivity (n = 20)

	Egg	L1	L2	L3	L4	L5	L6	Pupa
Duration ± SD	10.5 0.51	1.0 0.00	8.0 0.44	6.0 0.64	7.0 0.37	6.5 1.23	6.0 1.54	315.0 5.70

(max. 29) days, fecundity 150–200 (max. 271) eggs. About 100–120 eggs were deposited within 1–2 days after copulation under laboratory conditions, usually in one batch.

Epicopeia hainesii Holland, 1889

This species was observed in northern Vietnam, Tam Dao Mts., 75 km North of Hanoi, at an elevation of ca. 800–900 m (21°30′ N, 105°40′ E) only: 10.X.1984, ♂; 11.–22.IX.1988, 2♂♂; 5.VI.–8.VII.1991, 5♂♂, ♀; 15.–31.VIII.1993, ♂; 25.V.–13.VI.1995, 24♂♂. The locality is a small ridge, reaching over 1200 m, covered by 19,000 ha of evergreen montane rain forest (cf. Spitzer *et al.*, 1993). The adults fly in the evening and at night, with flight activity starting just after sunset. The males fly above the trees usually from 18:00 until it becomes dark. They are readily attracted to light shortly after sunset (from 19:00 to 20:00). Only one female was caught by a light trap and no eggs were laid.

Conclusions

Epicopeia mencia is strictly associated with *Ulmus* spp. (Ulmaceae) of the East Palaearctic temperate deciduous forests (cf. Janet, 1913; Strelkov, 1932; Jaroš *et al.*, 1992; Yen *et al.*, 1995). The adults are diurnal and heliophilous with peak flight activity occurring in the afternoon. The species is monovoltine in northern Korea and it hibernates at the pupal stage. In Taiwan a polyvoltine life cycle was observed (Yen *et al.*, 1995). It is easy to rear in the laboratory. The pupa can survive the rigorous Korean winter in the soil. The laboratory mortality is very low.

Epicopeia hainesii is a subtropical–tropical species, and was collected by the authors only in the montane cloud rain forest in northern Vietnam. The food plant is not *Lindera* spp. (Lauraceae) (cf. Janet, 1913), but plants of the genus *Cornus* (Cornaceae) (Yen *et al.*, 1995). The adults are nocturnal with activity starting just after sunset and are attracted by light. The species is probably polyvoltine (bivoltine?) in Vietnam. It is stenotopic and very characteristic of tropical cloud rain forest distributed in some parts of the southern East Palaearctic Region and northern Oriental Region (Janet, 1913; Yen, 1995 and pers. comm.). The ranges of both species do not appear to overlap.

There are no records of these two species coming into contact in southern China nor in other parts of their distribution, except of Taiwan (see Heppner & Inoue, 1992 and Yen *et al.*, 1995). *E. mencia* and *E. hainesii* are mimics (probably Batesian) of *Atrophaneura* spp., and perhaps *Pachliopta* spp. (Papilionidae), which are present at the localities in Korea and Vietnam (cf. Jaroš *et al.*, 1992; Spitzer *et al.*, 1993).

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Low-melting point paraffin used to close puncture wounds improves success of ecdysis triggered by ecdysone injection

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Summary. The injection of ecdysone into pupae of Sphingidae (Lepidoptera) is more successful when the puncture wound is closed with low-melting point paraffin instead of soluble collodion, the common approach in this field. As a result of this change in procedure, the rate of flawless eclosion increased from 1:3 (Loeliger & Karrer, 1996) to more than 9:10 ($p = 0.005$). Glue and polish were found to be even more noxious than collodion. Mastering the paraffin closure technique requires no more than a little practice. Ecdysone-induced synchronisation of the eclosion of adults which under mid-European climatic conditions only haphazardly enter metamorphosis, a notorious example being *Hyles centralasiae siehei*, will easily be obtained with this new technique for closure of the puncture wound.

Zusammenfassung. Die Erfolgsrate der Injektion von Ecdyson in Puppen von Schwärmern (Sphingidae, Lepidoptera) ist höher, wenn die Einstichwunde mit niedrigschmelzendem Paraffin verschlossen wird anstelle von gelöstem Kollodium, wie es gemeinhin üblich ist. Als Ergebnis dieses geänderten Vorgehens stieg die Rate fehlerlos geschlüpfter Tiere von 1:3 (Loeliger & Karrer, 1996) auf mehr als 9:10 ($p = 0.005$). Klebstoff und Lack erwiesen sich als noch schädlicher als Kollodium. Die Paraffin-Verschlusstechnik erfordert nur wenig Übung. Durch Ecdyson lässt sich die Synchronisierung des Schlupfs der Imagines mancher Arten induzieren, die unter mitteleuropäischen Klimabedingungen nur sporadisch metamorphosieren; ein notorisches Beispiel ist *Hyles centralasiae siehei*. Mit der neuen Technik zum Verschluss der Injektionswunde wird dies leicht zu erzielen sein.

Résumé. L'injection d'ecdysone en des chrysalides de Sphingidae (Lepidoptera) est mieux couronnée de succès quand la blessure causée par celle-ci est fermée au moyen de paraffine fusible à basses températures, plutôt qu'avec du collodion soluble, l'approche habituelle en ce domaine. Suite à ce changement de procédure, la proportion d'éclosions parfaites augmenta de 1:3 (Loeliger & Karrer, 1996) à plus de 9:10 ($p = 0.005$). La colle et la laque s'avérèrent encore plus nocives que le collodion. La maîtrise de la technique de la fermeture à la paraffine ne demande qu'un peu de pratique. La synchronisation de l'éclosion des adultes, qui n'entrent qu'accidentellement en métamorphose sous les conditions climatiques d'Europe centrale, est rendue possible par l'ecdysone, un exemple notoire en étant fourni par *Hyles centralasiae siehei*.

Key words: Lepidoptera, Sphingidae, metamorphosis, ecdysone.

Introduction

Shortly after the publication on the induction of metamorphosis of Lepidoptera by means of the injection of ecdysone or 20-hydroxy-ecdysone (Loeliger & Karrer, 1996), Spanish researchers pointed out by letter their experience with the ecdysone-induced metamorphosis of *Graellsia isabellae* (Graëlls, 1849) four years earlier (Ylla & Bellés, 1992). These authors had treated their pupae without anesthesia and without wound coverage. The pupae had been immobilized by exposure to ice for 10–15 minutes. The eclosing moths were flawless. Herewith, the authors indirectly suggested that collodion coverage of the wound might be toxic and therefore responsible for the low rate of flawless eclosion. Unfortunately, exposure to ice as applied by the Spanish researchers only insufficiently immobilizes pupae of Sphingidae and large amounts of lymph may be lost already before the injection site can be closed, resulting in insufficient unfolding of the wings upon eclosion. Nevertheless, the excellent results as obtained by the Spanish authors were an incentive to look for expert advice. We turned to professor Gilbert of the Biology Department of the University of North Carolina at Chapel Hill, a well-known expert in the field of endocrine control of moulting (Gilbert, 1989). By letter, he explained that "The procedure for closing a wound elicited by an injection is very simple. First, you make sure that the surface of the wound area is completely dry and then add a very small drop of a low-melting point paraffin that has been heated on a needle"; and: "I am sure that with very little practice you will master the technique". Hereupon, we decided to undertake further experimentations.

Materials and methods

Collodion: 3% dinitrocellulose in ethanol/diethylether 20/77.

Glue: marketed under the trade name *UHU Alleskleber* in Germany and Switzerland, produced by UHU G.m.b.H., Bühl (D).

Polish: marketed under the trade name *Bourgois, Formule aux Protéines*, Paris (F).

Both glue and polish were applied by means of thin paint brushes, in one or two rapidly drying layers.

Paraffin: Paraffinum solidum 48–51. Pharmacopoeia Nederlandica VI.

Injection technique: as described earlier (Loeliger & Karrer, 1996). For the site of injection, we randomly chose the traditional apex of the head of the pupa as well as the abdomen, i.e., segment 5 between the anterior midline and the right-hand spiracle.

Application of paraffin: the head of an ordinary pin (synthetic material, 3.5 mm diameter) was immersed in liquid paraffin heated to the boiling point and, after a few seconds, abruptly removed; as a rule a substantial droplet hung from the head of the pin. After rapid transfer to the puncture wound in the cuticle of the pupa, the drop coagulated almost instantaneously.

Live stock: Hyles centralasiae siehei pupae obtained from larvae collected in 1995 in two different parts of Turkey, kindly placed at our disposal by F. Renner, Erbach Ringingen (D), and purchased by one of us (FK), respectively. From some of the latter parasitoids emerged. One pupa of each of the two series displayed spontaneous metamorphosis in the spring of 1997, the emerging adults being crippled, however.

Hyles euphorbiae mauretanica: non-inbred eggs kindly supplied by H. Harbich, Salz (D). Loss-free breeding (EAL) of larvae resulted in flawless pupae.

Hyles euphorbiae dahlii: apparently healthy pupae obtained from mature larvae collected just before pupation in Sardinia (I), purchased by one of us (FK).

Results

Table 1 summarizes the results obtained with three different materials used for wound closure after uncomplicated ecdysone injection into non-hybrid pupae of two Sphingidae species. Males and females are not shown separately as there was no difference in eclosion rates between the two sexes.

Of the *Hyles euphorbiae* pupae, those belonging to the subspecies *mauretanica* apparently were the healthiest: the 14 pupae treated with paraffin all displayed flawless eclosion irrespective of whether the ecdysone had been injected via the apex of the head deep into the thorax or via the abdominal segment into the abdomen. Accordingly, the vitality and mating behaviour of the imagines were normal with abundant progeny, the number

Table 1. Results of uncomplicated ecdysone injection into non-hybrid pupae of Sphingidae (Lepidoptera)

	Number injected		Wound closure		with	Flaws		
	head	abdomen	glue	polish	paraffin	none	slight	severe
H. centralasiae siehei	5	1			6	5		1
H. euphorbiae dahlii	3	4	7				1	6
	2	3		5			4	1
	2	2			4	2	2	
H. euphorbiae mauretanica	10	4			14	14		
Total:	22	14	7	5	24	21	7	8

Note. Of the paraffin-treated pupae, only one adult did not eclose and develop normally; of the 12 glue and polish-treated pupae, 5 produced slightly and 7 severely defective imagines (p χ^2, < 0.005 if none and slight flaws are taken together). Injection via head resulted in a success rate similar to that via abdomen (p χ^2, > 0.25).

of eggs deposited by one of the females on *Euphorbia* exceeding 300.

All four *Hyles euphorbiae dahlii* pupae treated with paraffin emerged, although two of them displayed some defects. In sharp contrast, none of the 12 pupae treated with either glue or polish resulted in normal imagines, 7 being severely defective. However, also those treated with paraffin had low vitality. Mating did not occur in spite of conditions similar to those prevailing for *Hyles euphorbiae mauretanica* moths. Dissection of the females revealed a strikingly low number of apparently mature eggs.

For *Hyles centralasiae siehei*, the results were as follows. The two spontaneously developing pupae both produced abnormal adults. One female emerging from an injected pupa displayed obstruction of the cloaca, pointing to some kind of disturbed intestinal function of the caterpillar at the time of pupation. However, five of the six pupae injected, the injection wound being closed with paraffin, appeared to be suitable for mating and oviposition, although the conspicuous restlessness known for moths of this species hampers their feeding and causes wing damage such that flying is no longer possible after one week. Three of these five, one female and two males, emerged on July 2nd and were placed together in a gauze-covered circular cage 65 cm across and 80 cm high, in a large well-ventilated and daylight-illuminated loft. Mating took place within the first 24 hours after eclosion, the night being cold (lowest temperature 10°C) due to brightness of the sky. There was no moonlight illumination as new moon occurred on 3/4 July. Copulation, observed when the second male was still flying, lasted from 22:00 till 04:00, when the position of the pair had changed from vertical to horizontal. Room temperature had decreased from 19°C to 17°C. Oviposition could be observed from the second day after copulation on. Deposition of the eggs occurred exclusively on the gauze of the cage in the centre of which a bouquet of abundantly flowering *Kniphofia* (Liliaceae) had been placed, flowers which had been accepted for oviposition in earlier experiments. The female died eight days after mating, after having deposited 14 eggs, all sterile, however. On dissection only 85 more of apparently mature oocytes were counted.

Discussion and conclusion

As pointed out in the Introduction above, toxicity of collodion was suggested indirectly by Spanish researchers, who observed a 100% flawless eclosion rate after injection of ecdysone into pupae, the puncture wound of which not being covered with this rapidly drying material. Collodion consists of solid dinitrocellulose. Of its dissolvent, an ethanol/diethyl ether mixture, the alcohol component is unlikely to be toxic as it is also used to dissolve ecdysone. Ether, however, is a well-known neurotoxic substance, which indeed might be responsible for the rather high failure rate observed in our earlier experiments with ecdysone injections and coverage of the puncture site with collodion (Loeliger & Karrer, 1996).

The procedure as suggested by Gilbert for closing the wound elicited by the ecdysone injection appeared easy to apply and haemolymph leakage no longer ever occurred. More important, in contrast to what we had observed for glue, polish and collodion, paraffin obviously causes no toxic damage despite the fact that it enters the pupa in small amounts, as demonstrated microscopically. (Sucking in of the material is the result of the negative intrapupal pressure which develops during the cooling down period when CO_2 vapour emerges from the dry ice crystals and surrounds the pupa).

It is perhaps astonishing that no difference in eclosion success was observed between pupae injected via the apex of the head deep into the thorax and those injected intra-abdominally. But the small amount of injected fluid obviously does not disturb the loose anatomical structures of the thorax and abdomen.

Lastly we warn not to rely on too short a dissolution time for the crystalline ecdysone, the dissolution rate of which is directly proportional to its surface area. Larger crystals take up to half an hour at room temperature to dissolve.

In conclusion, low-melting point paraffin appears to be **the** material of choice for non-toxic and safe closure of the wound made by the injection needle during ecdysone treatment of pupae of Sphingidae. After injection of appropriate amounts of the hormone, normal development can be expected for healthy pupae, resulting in adults which easily mate and produce normal amounts of fertile eggs. Synchronisation of eclosion and breeding

of even the most difficult species, such as *Hyles centralasiae siehei*, which as far as we know has never been successfully bred in captivity, should now be feasible.

Acknowledgements

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On the identity of *Polyommatus* (*Agrodiaetus*) *dama*, with lectotype designation and redescription of its karyotype (Lycaenidae)

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Summary. The karyotype of *Polyommatus* (*Agrodiaetus*) *dama* (Staudinger, 1892) from near Malatya, in central-eastern Turkey, is described and figured: the haploid chromosome number $n = 41$ has been identified, quite in agreement with the results of de Lesse (1959c). Syntopic and synchronous occurrence of *P.* (*A.*) *dama* with the nominal taxa *P.* (*A.*) *poseidon* (Herrich-Schäffer, [1851]), *P.* (*A.*) *hopfferi* (Herrich-Schäffer, [1851]) and *P.* (*A.*) *theresiae* Schurian, van Oorschot & van den Brink, 1992 is confirmed, old historical specimens of both *P.* (*A.*) *dama* and *P.* (*A.*) *theresiae* from "Hadjin" (now Saimbeyli in Turkey, Adana province) having been located at the Museum für Naturkunde der Humboldt-Universität zu Berlin. All four taxa further differ markedly morphologically and karyologically, additionally supporting their specific distinctness. The identity of *P.* (*A.*) *dama* is established by designation of a lectotype. Similarities between *P.* (*A.*) *dama* from Malatya and the nominal taxa *P.* (*A.*) *dama karindus* (Riley, 1921) and *P.* (*A.*) *hamadanensis* (de Lesse, 1959), both from the Zagros Mts. in Iran, are underlined and their placement in a distinct *P.* (*A.*) *dama* group is advocated. While the current status of *P.* (*A.*) *dama karindus* (subspecies of *P.* (*A.*) *dama* or distinct species) is at present unresolved as its chromosome number and karyotype remain unknown, *P.* (*A.*) *hamadanensis* is definitely a distinct species, with a haploid chromosome number of $n = 21$–22 (de Lesse, 1959a). Syntopic and synchronic occurrence of both Iranian taxa is confirmed. Current evidence fully agrees with the view that de Lesse (1959c) correctly identified the specimens he ascribed to *P.* (*A.*) *dama*.

Zusammenfassung. Der Karyotyp von *Polyommatus* (*Agrodiaetus*) *dama* (Staudinger, 1892) aus der Zentraltürkei (Umgebung von Malatya) wird beschrieben und abgebildet. In Übereinstimmung mit Angaben von de Lesse (1959c) beträgt der haploide Chromosomensatz $n = 41$. Das syntope und synchrone Auftreten von *P.* (*A.*) *dama* mit den nominellen Taxa *P.* (*A.*) *poseidon* (Herrich-Schäffer, [1851]), *P.* (*A.*) *hopfferi* (Herrich-Schäffer, [1851]) und *P.* (*A.*) *theresiae* Schurian, van Oorschot & van den Brink, 1992, wird bestätigt, unter anderem durch die Entdeckung historischer Exemplare aus "Hadjin" (heute Saimbeyli, Prov. Adana, Türkei) im Museum für Naturkunde

der Humboldt-Universität zu Berlin. Die genannten vier Taxa sind morphologisch und karyologisch deutlich verschieden, was ihren Artstatus bestätigt. Die Identität von *P.* (*A.*) *dama* wird durch Designation eines Lectotypus fixiert. Ähnlichkeiten zwischen *P.* (*A.*) *dama* aus Malatya und den nominellen Taxa *P.* (*A.*) *dama karindus* (Riley, 1921) und *P.* (*A.*) *hamadanensis* (de Lesse, 1959), die beide aus dem Zagros-Gebirge in Iran beschrieben wurden, legen nahe, diese drei Taxa in einer eigenen Artengruppe zusammenzufassen. Der Status von *P.* (*A.*) *dama karindus* (Unterart von *P.* (*A.*) *dama* oder eigene Art?) kann derzeit mangels karyologischer Daten nicht geklärt werden, während *P.* (*A.*) *hamadanensis* mit einem haploiden Chromosomensatz von $n = 21–22$ (de Lesse, 1959a) als distinkte Spezies aufgefaßt wird. Das syntope und synchrone Vorkommen beider iranischer Taxa wird bestätigt. Alle verfügbare Evidenz zur Karyologie und Verbreitung bestätigt, dass de Lesse (1959c) die seinen Arbeiten zugrundeliegenden Exemplare korrekt als *P.* (*A.*) *dama* identifizierte.

Résumé. Le caryotype de *Polyommatus* (*Agrodiaetus*) *dama* (Staudinger, 1892) des environs de Malatya, en Turquie du centre-est, est décrit et figuré: le nombre haploïde de chromosomes $n = 41$ a été déterminé, en total accord avec les résultats obtenus par de Lesse (1959c). La cohabitation dans le même endroit, au même moment, de *P.* (*A.*) *dama* avec les taxa nominaux *P.* (*A.*) *poseidon* (Herrich-Schäffer, [1851]), *P.* (*A.*) *hopfferi* (Herrich-Schäffer, [1851]) et *P.* (*A.*) *theresiae* Schurian, van Oorschot & van den Brink, 1992 est confirmée, des exemplaires historiques anciens d'aussi bien *P.* (*A.*) *dama* que de *P.* (*A.*) *theresiae* en provenance de "Hadjin" [actuellement Saimbeyli en Turquie, province d'Adana] ayant été retrouvés au Museum für Naturkunde der Humboldt-Universität zu Berlin. De plus, ces quatre taxa diffèrent clairement tant par leur morphologie extérieure que du point de vue caryologique, ce qui corrobore leur statut spécifique. L'identité de *P.* (*A.*) *dama* est établie par la désignation d'un lectotype. Des similitudes marquantes entre *P.* (*A.*) *dama* de Malatya et les taxa nominaux *P.* (*A.*) *dama karindus* (Riley, 1921) et *P.* (*A.*) *hamadanensis* (de Lesse, 1959), tous deux en provenance des monts Zagros en Iran, sont soulignées, justifiant leur placement au sein d'un groupe distinct autour de *P.* (*A.*) *dama*. Alors que le statut actuel de *P.* (*A.*) *dama karindus* (sous-espèce de *P.* (*A.*) *dama* ou espèce distincte) ne peut être résolu tant que son nombre de chromosomes et son caryotype resteront inconnus, *P.* (*A.*) *hamadanensis* est certainement une espèce distincte, ayant un nombre haploïde de chromosomes $n = 21–22$ (de Lesse, 1959a). La coexistence des deux taxa iraniens est confirmée. Les données présentées ici tendent à prouver que de Lesse (1959c) identifia correctement les exemplaires qu'il attribua à *P.* (*A.*) *dama*.

Key words: Lycaenidae, *Polyommatus* (*Agrodiaetus*) *dama, Polyommatus* (*Agrodiaetus*) *dama karindus, Polyommatus* (*Agrodiaetus*) *hamadanensis, Polyommatus* (*Agrodiaetus*) *theresiae, Polyommatus* (*Agrodiaetus*) *poseidon, Polyommatus* (*Agrodiaetus*) *hopfferi*, karyotype, Turkey, Iran.

Introduction

Staudinger (1892: 234–235) described "*Lycaena Dama* Stgr." after a large series collected by Johann J. Manisadjian near Malatya in central-eastern Turkey in late July 1884. This butterfly

cannot be confused with any other *Polyommatus* (*Agrodiaetus*) species group taxon occurring in Turkey, being highly characteristic by its large size, its wing shape and the complete absence of any trace of a white streak on hindwing underside in both sexes (figs. 2–13, 20; for a detailed description see Staudinger, *loc.cit.*; Forster, 1961: 42–44 and Hesselbarth *et al.*, 1995: 727, Taf. 118).

Recently, Schurian & Eckweiler (1997) reported their rediscovery of *P.* (*A.*) *dama* near Malatya and questioned the mention by de Lesse (1959c), as they both did not find the specimens referred to by this author in the Muséum National d'Histoire Naturelle, Paris. As material ascribed to *P.* (*A.*) *theresiae* Schurian, van Oorschot & van den Brink, 1992 from Taşkent (Turkey, Konya province) has a haploid chromosome number of $n = 41$–42 (Kandul & Lukhtanov, 1997), i.e. exactly the same number as *P.* (*A.*) *dama* sensu de Lesse (1959c), the authors of the present contribution decided, in early August 1997, to try to locate topotypical material of both *P.* (*A.*) *dama* and *P.* (*A.*) *theresiae* and to fix testes for karyological examination. The results of our study of *P.* (*A.*) *theresiae* that, quite unexpectedly, lead to the description of a new species, have been dealt with elsewhere (Olivier *et al.*, 1999): here those with *P.* (*A.*) *dama* are discussed at length.

Material and methods

In 1997, only one single rather fresh, but damaged ♂ of *P.* (*A.*) *dama* (figs. 10–11) was collected in a habitat near Malatya, kindly communicated to us by Dr. Klaus G. Schurian. The testes were fixed almost immediately after collecting and, later on, a slide mount (97019/1 (WDP)) was prepared by Dr. Seppo Nokkala, who also made the photograph reproduced here on fig. 1 (methodology followed as described in Olivier *et al.*, 1999).

Karyotype of *Polyommatus* (*Agrodiaetus*) *dama*

The haploid chromosome number identified is $n = 41$. The karyotype is exactly asymmetric. The bivalents are round shaped and form two distinct groups which strongly differ in size: one group of 11 large bivalents forms a dimensional series in size,

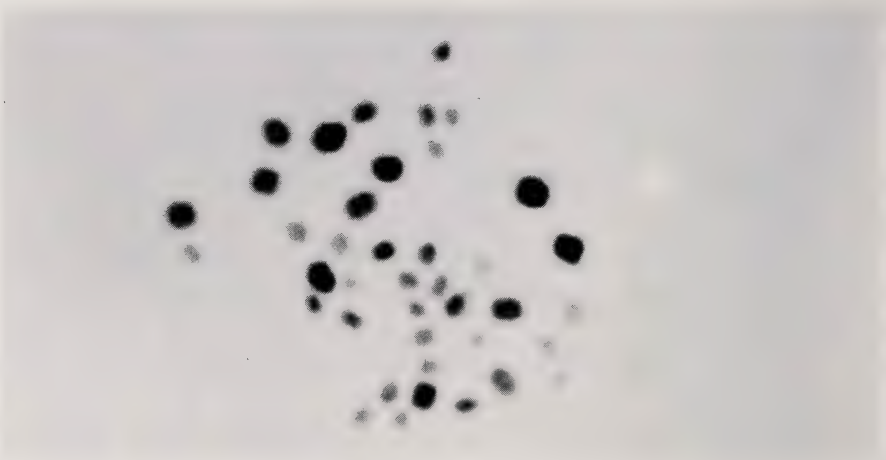

Fig. 1. Karyotype of *Polyommatus* (*Agrodiaetus*) *dama*, prep. 97019/1 (S. Nokkala), *M*-I, Turkey, Malatya province, vic. Malatya, 1200 m, 5.VIII.1997, leg. W. De Prins, A. Olivier & D. van der Poorten, in coll. Vlaamse Lepidoptera Collectie Antwerpen.

while the other group of 30 medium-sized bivalents accounts for about 40–50% of the area of the bivalents of the first group. The large bivalents are situated in two compact groups of the metaphase plate (*M*-I). The medium-sized bivalents are isopycnotically less stained, almost of equal size, showing only a very slight degree of diminution. Most of these are located in the centre of the metaphase I plate. No additional elements or univalents were observed, nor were telomeric associations between the bivalents. It is noteworthy that the karyotype figured by de Lesse (1959c: 312, fig. 1) shows the medium-sized bivalents to be situated at the edge of the plate. The differences observed could be due to the fact that, in irregular plates such as in our preparation, due to the squashing technique or hypotonic solution treatment, the place of certain chromosomes can vary.

Sympatry with other *Polyommatus* (*Agrodiaetus*) species-group taxa and differentiating characters

Near Malatya, we found *P.* (*A.*) *dama* to be syntopic and synchronous with a.o. *P.* (*A.*) *poseidon* (Herrich-Schäffer, [1851])

and *P.* (*A.*) *hopfferi* (Herrich-Schäffer, [1851]). Material of *P.* (*A.*) *poseidon* (figs. 18–19), however, can easily been told apart by the distinctly lighter blue colour of the ♂, the generally somewhat smaller size and the presence of a white streak (though not always very clearly) on underside hindwing in both sexes. Staudinger (1892: 233–234) described the population of *poseidon* from near Malatya as "*Lycaena Poseidon* Led. var. *Mesopotamica* Stgr.", which is at present generally considered to be a junior subjective synonym of *Polyommatus* (*Agrodiaetus*) *poseidon poseidon* (Herrich-Schäffer, [1851]) (Schurian *et al.*, 1992: 222; Hesselbarth *et al.*, 1995: 726, but see Eckweiler & Häuser, 1997: 120, 155). We fixed material from near Malatya and found $n = 20$ (Olivier, De Prins & van der Poorten, unpublished). The chromosome number of *P.* (*A.*) *poseidon* varies from $n = 18$ to $n = 27$ (de Lesse, 1963; Kandul & Lukhtanov, 1997) and it is quite possible that it covers more than one species. Anyway, it differs significantly from that of *P.* (*A.*) *dama*.

P. (*A.*) *hopfferi* (fig. 21) also cannot be confused with *P.* (*A.*) *dama*. It is only of anecdotic interest to report that Staudinger (1892: 234–235) emphasized the sometimes close resemblance of both taxa on the underside (the upperside is completely different, being yellowish-, greenish- or bluish-grey in *hopfferi* ♂). The chromosome number of *P.* (*A.*) *hopfferi* is $n = 15$–16 (de Lesse, 1959b, 1959c, 1960; Lukhtanov *et al.*, 1998), additionally supporting the specific distinctness of *hopfferi* and *dama*.

Olivier *et al.* (1999) discussed at length the suggestion by Kandul & Lukhtanov (1997) and Lukhtanov *et al.* (1998) that *P.* (*A.*) *dama and P.* (*A.*) *theresiae* could possibly be subspecies, on account of their supposedly allopatric distribution and similar chromosome number. Obviously, this is not the case: during a visit to the Museum für Naturkunde der Humboldt-Universität zu Berlin by the first author in late November 1998, one ♂ specimen of *P.* (*A.*) *dama* was found that bears a label "Hadjin | [18]84 Man.[isadjian]" (figs. 12–14), i.e. that was collected in the very type locality of *P.* (*A.*) *theresiae*, now named Saimbeyli (Turkey, Adana province) and, a few days later, Dr. Yuri P. Nekrutenko (pers. comm.) also found a genuine *P.* (*A.*) *theresiae* specimen from "Hadjin" (figs. 15–17) in the Püngeler collection at the Museum für Naturkunde der Humboldt-Universität zu

Berlin (these two specimens are probably the ones referred to by Staudinger (1892: 234) under "*Lycaena Poseidon* Led. var. *Mesopotamica* Stgr." as "...aus Hadjin ein paar ♂♂ einer ähnlichen etwas grösseren Form mit etwas verschiedenem Blau der Oberseite..."). Furthermore, the chromosome number of *P.* (*A.*) *theresiae* is $n > 59$, presumably 63 (Nokkala found $n = 65$–66, cf. Olivier *et al.*, 1999). Finally, the latter taxon always has a white streak on underside hindwing in both sexes and a striking androconial patch on ♂ upperside forewing. It thus appears that the nominal taxa *P.* (*A.*) *dama*, *P.* (*A.*) *poseidon*, *P.* (*A.*) *hopfferi* and *P.* (*A.*) *theresiae* do occur (or have occurred) in sympatry at Saimbeyli (Hesselbarth *et al.*, 1995; this study) and, the more, differ significantly both morphologically and karyologically. It can therefore be concluded that all are specifically distinct.

Lectotype designation

Considering the confusion that has repeatedly aroused around its identity (vide supra), and in order to establish it ultimately, a lectotype of *Polyommatus* (*Agrodiaetus*) *dama* (figs. 2–4) is designated here.

> *Lycaena Dama* Stgr. n. sp." Staudinger, O., 1892. Neue Arten und Varietäten von Lepidopteren des paläarktischen Faunengebiets. — *Dt.ent.Z.Iris* 4(1891): 234–235 (Mitte Februar 1892). Type locality: "...bei Malatia..." (now Turkey, Malatya province, vic. Malatya).

– **Lectotype** ♂, with labels: handwritten (Staudinger) "Dama | Stgr." (on white paper), handwritten "Malatia | [18]84 Man.[issadjian]" (on yellow paper), printed "Origin." (on pink paper), printed "Zool. Mus. | Berlin" (on pale yellow paper), printed with handwritten (P. S. Wagener) inscriptions "Abgebildet in Hesselbarth | van Oorschot & Wagener: | Tagfalter der Türkei. | Tafel *118* Figur *29*" (on white paper), printed

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Figs. 2–9. *Polyommatus* (*Agrodiaetus*) spp.: 2 — *P.* (*A.*) *dama* (Staudinger, 1892), lectotype ♂ (upperside), [Turkey, Malatya province], [vic.] Malatya, [late July] 1884, leg. Manisadjian, in coll. Museum für Naturkunde der Humboldt-Universität zu Berlin; 3 — same (underside); 4 — same (labels); 5 — *P.* (*A.*) *dama* (Staudinger, 1892), paralectotype ♀ (upperside), [Turkey, Malatya province, vic. Malatya, late July 1884, leg. Manisadjian], in coll. Museum für Naturkunde der Humboldt-Universität zu Berlin; 6 — same (underside); 7 — same (labels); 8 — *P.* (*A.*) *dama* (Staudinger, 1892), paralectotype ♂ (upperside, aberrant ground-colour); 9 — same (underside).

2

3

4

Dama
sp.
ex coll. 1/10
STAUDINGER
Origin.
Zool. Mus.
Berlin
Abgebildet in Hesselbarth,
van Oorschot & Wagener:
Tagfalter der Türkei
Tafel 118 Figur 23

5

6

7

Origin.
ex coll. 9/10
STAUDINGER

8

9

"*Lycaena Dama* Staudinger, 1892 | LECTOTYPUS ♂ | design. Olivier, De Prins, van | der Poorten & Puplesiene, 1999" (on red paper); in coll. Museum für Naturkunde der Humboldt-Universität zu Berlin.

- **Paralectotypes** 5♂, 4♀, with circles of yellow locality label paper, printed "Origin." (on pink paper), some with small date labels, and printed "Zool. Mus. | Berlin" (on pale yellow paper); one ♂ bears also new handwritten labels "20." (on cross-lined notebook paper) and "dama" (on white paper), one ♂ with handwritten label (Staudinger) "Dama | Stgr." (on white paper) and handwritten date label "25/7" (on white faded paper), one ♀ with handwritten label "21." (on cross-lined notebook paper), handwritten (Wagener) "Lycaena dama | Stgr. 1892 ♀ | Malatia 84 Man." (on white paper) and printed with handwritten (P. S. Wagener) inscriptions "Abgebildet in Hesselbarth | van Oorschot & Wagener: | Tagfalter der Türkei. | Tafel *118* Figur *52* <recte: *49*>" (on white paper), 5 times printed "*Lycaena Dama* Staudinger, 1892 | PARALECTOTYPUS ♂ | design. Olivier, De Prins, van | der Poorten & Puplesiene, 1999" (on red paper), 4 times printed "*Lycaena Dama* Staudinger, 1892 | PARALECTOTYPUS ♀ | design. Olivier, De Prins, van | der Poorten & Puplesiene, 1999" (on red paper); all in coll. Museum für Naturkunde der Humboldt-Universität zu Berlin.

Through the courtesy of Dr. Axel Hausmann, we received a small series of *P.* (*A.*) *dama* (3♂, 2♀) on loan from the Zoologische Staatssammlung München, including 2♂, 2♀ that each bear a handwritten label "Cotypus | Lycaena ♀ | dama Stgr" (on pink paper). We are not convinced, however, that any of these specimens actually belonged to the original syntype series and therefore we do not list any of these specimens among the paralectotypes of *P.* (*A.*) *dama* (see also Hesselbarth *et al.*, 1995: 727).

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Figs. 10–17. *Polyommatus* (*Agrodiaetus*) spp.: 10 — *P.* (*A.*) *dama* (Staudinger, 1892) ♂ (upperside), Turkey, Malatya province, vic. Malatya, 1200 m, 5.VIII.1997, leg. W. De Prins, A. Olivier & D. van der Poorten, in coll. Vlaamse Lepidoptera Collectie Antwerpen, specimen examined karyologically, prep. 97019/1 (S. Nokkala), cf. fig. 1; 11 — same (underside); 12 — *P.* (*A.*) *dama* (Staudinger, 1892) ♂ (upperside), [Turkey, Adana province], Hadjin [Saimbeyli], 1884, leg. Manisadjian, in coll. Museum für Naturkunde der Humboldt-Universität zu Berlin (excluded from type series); 13 — same (underside); 14 — same (labels); 15 — *P.* (*A.*) *theresiae* Schurian, van Oorschot & van den Brink, 1992 ♂ (upperside), [Turkey, Adana province], Hadjin [Saimbeyli], [leg. Manisadjian?], in coll. Museum für Naturkunde der Humboldt-Universität zu Berlin; 16 — same (underside); 17 — same (labels).

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Distribution of *P.* (*A.*) *dama* in Turkey

In Turkey, *P.* (*A.*) *dama* is now known from the provinces of Malatya, Maraş and Mardin (Hesselbarth *et al.*, 1995: 727) and from Adana province (this study). The record by Hesselbarth *et al.* (*op.cit.*: 727) from "Kubbe Dağı, 1990, HAN(ROSE, pers. Mitt.)" further has to be corrected as Adiyaman province, Nemrut Dağı Milli parkı (Hanus & Hoareau, 1998).

Systematic position of *P.* (*A.*) *dama*

Turkish *P.* (*A.*) *dama* shows striking similarities with the nominal taxa *P.* (*A.*) *dama karindus* (Riley, 1921) and *P.* (*A.*) *hamadanensis* (de Lesse, 1959), that were described resp. from "Harir, Karind, and Karind Gorge, N. W. Persia" (Iran, Zagros Mts., Bākhtarān (Kermānshāh) province — Riley, 1921: 597) and from "col route Kazvin à Hamadan (Iran W) env. 2350 m" (Iran, Zagros Mts., Hamadān province — de Lesse, 1959a: 14–15), in its size, wing shape and lack of the white streak on underside hindwing and it is probably not a coincidence that both Iranian taxa have originally been described as subspecies of *P.* (*A.*) *dama*.

According to Riley (1921: 597), Forster (1961: 44–45) and Hesselbarth *et al.* (1995: 727), *P.* (*A.*) *dama karindus* (figs. 22–23) differs from Turkish *P.* (*A.*) *dama* in the complete discal series of spots on hindwing underside and the stronger development

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Figs. 18–25. *Polyommatus* (*Agrodiaetus*) spp.: 18 — *P.* (*A.*) *poseidon* (Herrich-Schäffer, [1851]) ♂ (upperside), Turkey, Malatya province, vic. Malatya, 1200 m, 5.VIII.1997, leg. W. De Prins, A. Olivier & D. van der Poorten, in coll. Vlaamse Lepidoptera Collectie Antwerpen; 19 — same (underside); 20 — *P.* (*A.*) *dama* (Staudinger, 1892) ♂ (upperside), Turkey, Malatya province, vic. Malatya, 1400 m, 27.VII.1998, leg. D. van der Poorten & W. De Prins, in coll. Vlaamse Lepidoptera Collectie Antwerpen; 21 — *P.* (*A.*) *hopfferi* (Herrich-Schäffer, [1851]) ♂ (upperside), Turkey, Malatya province, vic. Malatya, 1200 m, 5.VIII.1997, leg. W. De Prins, A. Olivier & D. van der Poorten, in coll. Vlaamse Lepidoptera Collectie Antwerpen; 22 — *P.* (*A.*) *dama karindus* (Riley, 1921) ♂ (upperside), Iran, Zagros Mts., Lorestān province, Saravand Dorūd, 2000–2300 m, 2–5.VIII.1979, leg. E. Görgner, in coll. Vlaamse Lepidoptera Collectie Antwerpen; 23 — same (underside); 24 — *P.* (*A.*) *hamadanensis* (de Lesse, 1959) ♂ (upperside), Iran, Zagros Mts., Lorestān province, Saravand Dorūd, 2000–2300 m, 2–5.VIII.1979, leg. E. Görgner, in coll. Vlaamse Lepidoptera Collectie Antwerpen; 25 — same (underside).

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of the submarginal row of markings on underside in both sexes, as well as in the lighter blue ground-colour on ♂ upperside and the lighter brown ground-colour on ♀ upperside. We have compared a small series of 7♂ of nominotypical *P.* (*A.*) *dama* that we collected near Malatya (1997 & 1998) with 2♂ of *P.* (*A.*) *dama karindus* (all material in coll. Vlaamse Lepidoptera Collectie Antwerpen) and were able to partly confirm these differences in the ♂. Solving the question whether *karindus* really belongs to *dama* awaits the future identification of its chromosome number and karyotype (see Olivier *et al.*, 1999: 22–23 for a further discussion on the systematic value of such characters).

The chromosome number of "*Agrodiaetus dama hamadanensis*" was established as $n = 21–22$ by de Lesse (1959a); subsequently, when he established the chromosome number of nominotypical *dama*, de Lesse (1959c) raised *hamadanensis* to species level. *P.* (*A.*) *hamadanensis* ♂ (figs. 24–25) further differs markedly from *P.* (*A.*) *dama* by its dark violet ground-colour on upperside, which lead Hesselbarth *et al.* (1995: 706, 727) to place it in the "*carmon*-Gruppe" (van Oorschot, pers. comm.), a view we do not share. It has the submarginal row of markings on underside better expressed in both sexes, as compared to *P.* (*A.*) *dama*. Among material of the latter taxon, one occasionally encounters aberrant ♂ specimens that are dark greyish violet (Staudinger, 1892: 234, specimen figured here on figs. 8–9; de Lesse, 1959c: 312; Forster, 1961: 44), slightly reminiscent of *P.* (*A.*) *hamadanensis* in this respect.

Eckweiler & Häuser (1997: 133–134, plate 3) figure specimens of *P.* (*A.*) *dama karindus* and *P.* (*A.*) *hamadanensis* (leg. Eckweiler) collected on the very same spot, while in coll. Vlaamse Lepidoptera Collectie Antwerpen, there is also one single ♂ of *P.* (*A.*) *dama karindus* collected at the same locality and on the same day as a small series of *P.* (*A.*) *hamadanensis* (Iran, Zagros Mts., Lorestān province, Saravand Dorūd, 2000–2300 m, 2–5.VIII.1979, leg. Görgner; cf. figs. 22–25), confirming their specific distinctness.

We agree in the placement of the three nominal species group taxa discussed in this heading in a *P.* (*A.*) *dama* group, as suggested by Hesselbarth *et al.* (1995) and Eckweiler & Häuser (1997), though the former authors excluded *P.* (*A.*) *hamadanensis*,

as already stated, and the latter authors include *P.* (*A.*) *theresiae*, a taxon that in our view belongs to a different, i.e. the *P.* (*A.*) *transcaspicus*, group (Olivier *et al.*, 1999).

Le Cerf (1913: 69) lists "*L. dama* Stgr. Deh-Tcheshma, 31-VII-1898: 1♀" (now in Iran, Bākhtarān (Kermānshāh) province). The specimen could belong either to *karindus* or to *hamadanensis*: as we have not seen this specimen, we will not comment further on this issue.

Forster (1961: 46–47) described "*A.*[*grodiaetus*] *hamadanensis splendens*" from Keredji, in the Elburs Mts. (northern Iran) after one single ♂. Häuser & Eckweiler (1997: 102) correctly pointed out that the name is invalid, being a junior secondary homonym of *Polyommatus* (*Plebicula*) *escheri splendens* Stefanelli, 1904. We cannot comment on their statement that "A replacement is not needed, because *splendens* Forster, 1961 appears to be a subjective synonym of *Polyommatus* (*Agrodiaetus*) *hamadanensis*", as we have not seen the holotype.

Considering all that has been said here, we have every reason to consider that de Lesse (1959c) correctly identified the specimens he ascribed to *P.* (*A.*) *dama*.

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Notes on some Western Palaearctic species of *Bucculatrix* (Gracillarioidea, Bucculatricidae)

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Summary. The type material of 12 species of *Bucculatrix* Zeller, 1839 deposited in the Museum für Naturkunde Berlin is revised. *B. imitatella* Herrich-Schäffer, [1855], and *B. jugicola* Wocke, 1877, are sunk in synonymy of *B. cristatella* (Zeller, 1839). Two other synonyms have been established: *B. alpina* Frey, 1870 = *B. leucanthemella* Constant, 1895, **syn. n.**; *B. infans* Staudinger, 1880 = *B. centaureae* Deschka, 1973, **syn. n.** The male genitalia of the species are figured. Lectotypes have been designated for 5 species.

Zusammenfassung. Es wird das Typenmaterial von 12 Arten der Gattung *Bucculatrix* Zeller, 1839 revidiert, die sich im Museum für Naturkunde Berlin befinden. Zwei Namen stellten sich als neue Synonyme heraus: *B. imitatella* Herrich-Schäffer, [1855], **syn. n.** und *B. jugicola* Wocke, 1877, **syn. n.** von *B. cristatella* (Zeller, 1839). Zwei weitere Synonyme werden bekanntgemacht: *B. leucanthemella* Constant, 1895, **syn. n.** von *B. alpina* Frey, 1870 und *B. centaureae* Deschka, 1973, **syn. n.** von *B. infans* Staudinger, 1880. Für fünf Arten werden Lectotypen festgelegt.

Résumé. Le matériel-type de 12 espèces du genre *Bucculatrix* Zeller, 1839, déposé au Museum für Naturkunde Berlin, a été révisé. Deux noms sont apparus comme étant de nouveaux synonymes: *B. imitatella* Herrich-Schäffer, [1855], **syn. n.** et *B. jugicola* Wocke, 1877, **syn. n.** de *B. cristatella* (Zeller, 1839). Deux autres synonymes sont révélés: *B. leucanthemella* Constant, 1895, **syn. n.** de *B. alpina* Frey, 1870 et *B. centaureae* Deschka, 1973, **syn. n.** de *B. infans* Staudinger, 1880. Pour cinq espèces, un lectotype a été désigné.

Key words: Lepidoptera, Bucculatricidae, *Bucculatrix*, types, taxonomy, Europe, Turkey.

Introduction

The genus *Bucculatrix* Zeller, 1839 is a large group of leaf miners (at least as early instars) and gall makers. The genus has a worldwide distribution. More than 220 species have been recognised up till now (Heppner, 1991). A concentration of species can be observed in North America and Eurasia with about 100 and 80 species respectively (cf. Baraniak, 1996; Davies, 1963;

Seksjaeva, 1993). From other continents much lower numbers of species are known: South and Central America — 14, Africa — 21, South Asia — 10 (Heppner, 1991), Australia — 14 (Nielsen *et al.*, 1996). It is questionable if this contrasting diversity reflects a real difference between the northern and southern continental regions. South America, Africa and Australia are largely unexplored. A more intensive faunistic and taxonomic work in these areas will undoubtedly lead to the discovery of many more species. However, the discovery of unknown species in North America or Europe is by no means a closed chapter. New species descriptions are published frequently (e.g. Deschka, 1992a, b; Deschka & Huemer, 1997; Rubinoff & Osborne, 1997; Seksjaeva, 1996). The permanent addition of new species to the Western Palaearctic fauna was regrettably not accompanied by a taxonomic treatment of the genus nor prompted it such a synthetic study. Meanwhile the genus has become unwieldy and difficult to handle especially in the Mediterranean and adjacent regions. Many species are very similar both in genitalic characters and wing patterns. They are difficult to identify correctly without performing a comparison based on extensive material of all related species. Photographs and line drawings of the genitalia are often not sufficient enough to allow a clear separation. In addition, the type material of species established during the 19th Century (e.g. Constant, Millière, Chrétien, Staudinger, Frey, Herrich-Schäffer etc.) has hardly been a subject of revisionary studies, which had been followed by a subsequent publication of the results. The only exception is the account on the Scandinavian species by Svensson (1971). Thus, there are still a lot of associations between species and names, which are based on outdated opinions, new interpretations or conventions, but not on the types. Today, an examination of these types is a basic requirement because it helps to clarify specific names attribution and to stabilize the taxonomy of *Bucculatrix*.

During curatorial work on the Bucculatricidae material of the Museum für Naturkunde Berlin I found type specimens of a number of European *Bucculatrix* species. According to labels some of them have been studied earlier by Deschka, Hering and Patzak, but no comments or redescriptions have been published so far. The other part of type specimens apparently remained

untouched since Staudinger's time. Some specimens were inadequately labelled, and their status as types thus remains doubtful. Others were simply misplaced. It soon became obvious that a rearrangement of the *Bucculatrix* material could not be done without a revision of the type material. It is not my intention, however, to provide an elaborate revision of the species including a complete synonymy and detailed descriptions. These are issues for a monographic revision. Because a revision of the Western Palaearctic species cannot be expected to appear within the next years, a publication on the types deposited in the Museum für Naturkunde Berlin might be a helpful step towards taxonomic clearness in Bucculatricidae of the Western Palaearctic.

Methods

The structures of the genitalia are at a premium in recognition of the species-group taxa identity. Consequently, the genitalic characters were used extensively to define the species. The genitalic preparation followed common practice: maceration in boiling KOH, rinsing in distilled water, clarification in alcohol, staining with "Kongorot", embedding in Euparal as genital slide or in glycerine in a small tube attached to the pin, labelling. The figures of the genitalia were produced after staining and mounting all structures in natural position.

Abbreviations

NHML — The Natural History Museum, London,
MNHB — Museum für Naturkunde der Humboldt-Universität, Berlin.

List of species

Bucculatrix alpina Frey, 1870 (fig. 1)

B. alpina Frey, 1870: 287.
B. leucanthemella Constant, 1895, **syn. n.**

Lectotype ♂, (designated here) with handwritten label "Schweiz, Engadin, Sils Maria, Juli 1867", printed "Frey Coll. Brit. Mus. 1819-62"; genitalia slide labelled on printed form "Brit. Mus. (Nat. Hist). Microlepidoptera" with handwritten inscription "26610 ♂" designated with printed label on red paper "Lectotypus" (NHML).

Paralectotypes: ♂, same label data as of lectotype; genitalia preparation (glycerine tube pinned to the specimen) "Mey 4/1998" (NHML); 2♂, with handwritten (Herrich-Schäffer hand) label "n. sp. / Samaden", printed "H.-Sch.", coll. Herrich-Schäffer in coll. Staudinger, genitalia slide: Mey, 12/97 (MNHB); 2♂, ♀ with handwritten labels "19/7.[1867]", "Ob. Engadin, m.[ihi]" (both Staudinger hand), coll. Staudinger, genitalia slides (♂): Mey 5/97 (MNHB).

According to the original description, the type series was collected by Herrich-Schäffer, Nickerl, Staudinger and Frey during a joint excursion. The species was tentatively identified as *B. imitatella* H.- S. Later on, Herrich-Schäffer sent a specimen of his *B. imitatella* to Frey. He recognized the species as being quite different and described an alpine species as *B. alpina*. Herrich-Schäffer obviously came to the same conclusion, because he wrote on the label of his Engadin specimens "n. sp.". His collection, together with the Staudinger collection, is deposited now in the Museum für Naturkunde Berlin. While visiting the Natural History Museum in London in December 1997, I examined Frey's type specimens and found them to be conspecific with the specimens of Herrich-Schäffer and Staudinger. Since all the material was mentioned in the original description, it should be considered as belonging to the type series.

Comparison of material of *B. leucanthemella* Constant, 1895 in the Staudinger and Hinneberg collection (MNHB), collected by Constant in Cannes, revealed its conspecificity with *B. alpina*.

***Bucculatrix argentisignella* Herrich-Schäffer, [1855]** (figs. 2, 6, 7)

B. gracilella Frey, 1856 — Staudinger, 1901: 220.

Lectotype ♀ (designated here), with labels: printed on white paper "H.[errich]–Sch.[äffer]", printed on pink paper "Origin.", designated with printed label on red paper "Lectotypus"; genitalia slide Mey 14/97. Paralectotypes: 5♀, one with handwritten (Herrich-Schäffer hand) label on white paper in printed box "argentisignella / HS / *" and printed on pink paper "Origin.", no locality label; one with printed labels "H.–Sch." and "Origin", one with small handwritten "16/5 Klbg", two without labels; all from coll. Herrich-Schäffer, in coll. Staudinger (MNHB).

The Staudinger collection contains a couple of *B. argentisignella* H.-S. collected while in copula by Frey near Zürich. The sexual dimorphism in this species is thus obvious and very pronounced. The male has a uniform grey colour and lacks the four silvery spots on the forewings. Thus, the male resembles small specimens

of *B. cristatella* (Zeller, 1839), with which it was sometimes confused (cf. Leraut, 1997).

Bucculatrix atagina **Wocke, 1877** (fig. 3)

Lectotype ♂ (designated here), with labels: handwritten on green paper in printed box "Meran / 15.7.[18]76 Z[ucht] / Artem.[isia] camp.[estris]" printed on pink paper "Origin." printed on white paper "Genitalpräparat / No. [no number inscribed] / J. Klimesch, Linz a. D." designated with printed label on red paper "Lectotypus", coll. Staudinger (MNHB).

The genitalic armature in the slide is slightly distorted. However, the diagnostic characters are clearly visible. Figure 3 is made from another male specimen collected at the type locality.

Bucculatrix artemisiella **Herrich-Schäffer, [1855]**

No type specimens of *B. artemisiella* H.-S. were found in the Staudinger collection.

Bucculatrix basifuscella **Staudinger, 1880** (fig. 8)

Lectotype ♂ (designated here), with labels: handwritten on white paper "10/5", handwritten on yellow paper "Amasia m.[ihi] [10.5.1875]", printed on pink paper "Origin.", handwritten (Staudinger hand) on white paper "Basifuscella Stgr.". It is supplied now with a printed label on white paper with handwritten inscription "Genit. Unters. / Nr. *Deschka* / Zool. Mus. Berlin". coll. Staudinger, designated with printed label on red paper "Lectotypus" (MNHB). Paralectotypes: 2♀, 10.5. and 31.5.1875, same label data as lectotype (MNHB).

The genitalic structures of the species were never published. As far as I know the species is only known from the type locality. Certainly, it has a much wider distribution and perhaps is recorded under a different name.

The male genitalia are very peculiar, especially the shape of the valvae and the internal structure of the phallic complex.

The preparation consists of two slides: one for the genitalia and another for the rest of the abdomen (both labelled by Deschka).

Bucculatrix cristatella **(Zeller, 1839)** (figs. 11–13)

B. imitatella Herrich-Schäffer, [1855], **syn. n.**
B. jugicola Wocke, 1877, **syn. n.**

B. imitatella H.-S.: Holotype ♀ (by monotypy) with labels: handwritten (von Heyden hand?) "Juli vom Waldgras im / Taunusgebirge <illegible> / Fühler solang als <illegible>", handwritten (Herrich-Schäffer hand) on white paper in printed box "imitatella HS.", printed on pink paper "Origin.", coll. Herrich-Schäffer, in coll. Staudinger; designated with printed label on red paper "Holotypus" (MNHB).

B. jugicola: Lectotype ♂ (designated here), with handwritten (Wocke hand) label on white paper "Jugicola Wk.", handwritten on yellow paper "[Süd-Tirol] Trafoi / m. [ihi]", and printed on pink paper "Origin."; genitalia slide: Mey 4/97; designated with printed label on red paper "Lectotypus" (MNHB). Paralectotypes: 2♂, 5♀, with printed label on pink paper "Origin.". coll. Staudinger, (MNHB);

The holotype is almost completely destroyed. Only the head and the pro- and mesothorax have remained on the minuten. The colouration of frons, vertex, collar and frontal tuft is very similar to *B. cristatella* (Zeller, 1839). In the absence of any other diagnostic differences I consider the holotype of *B. imitatella* as conspecific with *B. cristatella*. Thus, *B. imitatella* is put into the synonymy of *B. cristatella*. This is also in accordance with the distributional area of *B. cristatella*, which extends from France to Russia. Further specimens in the collections of the MNHB identified by Herrich-Schäffer and Staudinger as *B. imitatella* proved to be *B. alpina*. This species is known to occur in France and Italy, under the name *B. leucanthemella* (Baraniak, 1996).

There are no clear morphological characters, both external and genitalic, that enable a differentiation between *B. jugicola* and *B. cristatella*. Klimesch (1942) noted a slight variability in the wing coloration of the alpine specimens, which is observable in lowland populations too. The long separation of *B. cristatella* and *B. jugicola* (e.g. Burmann, 1991) was probably maintained because of the different larval host plants in the Alps (*Chrysanthemum alpinum*) and in other regions (*Achillea millefolium*).

Interestingly, *B. jugicola* was already considered a synonym by Seksjaeva (1993: 107). However, she did not clearly indicate this new synonymy.

A male specimen of *B. jugicola* in NHML bears a lectotype label. This designation is unavailable, since the specimen does not belong to the original type series.

Bucculatrix demaryella **(Duponchel, 1840)** (fig. 10)

B. scoticella Herrich-Schäffer, [1855] — Rebel, 1901: 219.

B. scoticella: Holotype ♂ (by monotypy) with labels: printed on blue stripe-like paper "6. Demaryella, Sta[inton?]", handwritten (Herrich-Schäffer hand) on white paper in printed box "scoticella HS. / England", coll. Herrich-Schäffer, in coll. Staudinger, genitalia slide: Mey 10/97; designated with printed label on red paper "Holotypus" (MNHB).

The type specimen was sent to Herrich-Schäffer by Stainton. The dark pattern of the forewings is in strong contrast to specimens from Central Europe, and this obviously prompted Herrich-Schäffer to describe it as a distinct species. However, the genitalic preparation revealed the specimen to be conspecific with *B. demaryella* (Duponchel, 1840).

Bucculatrix humiliella **Herrich-Schäffer, [1855]** (figs. 4, 5)

B. fatigatella var. *obscurella* Klemensiewicz, 1899, **syn. n.**
B. capreella Krogerus, 1952 — Deschka, 1992b: 19.
B. merei Pelham-Clinton, 1967 — Svensson, 1971: 100; Deschka, 1992b: 19.

Lectotype ♀ (designated here), with labels: printed on white paper "H.[errich]-S.[chäffer]" and on pink paper "Origin.", "Genit. Unters. / Nr. Mey 7/97 / Zool. Mus. Berlin" coll. Herrich-Schäffer, in coll. Staudinger, designated with printed label on red paper "Lectotypus" (MNHB). Paralectotypes: ♂, 2♀, with the same printed labels, one bearing handwritten "Mai" and "851" (MNHB). Genitalia preparations: paralectotype ♀, Mey 8/97; paralectotype ♂, Mey 9/97 (MNHB).

The type series of *B. humiliella* was never examined. Therefore, in the absence of any illustrations, the species was treated as dubious or *incertae sedis* in the European literature (cf. Baraniak, 1996). However, the types have been available all the time in the MNHB. Their present examination shows them to represent a distinct species described under three different names in the past.

Bucculatrix infans **Staudinger, 1880** (fig. 9)

B. centaureae Deschka, 1973, **syn. n.**

Holotype ♂ (by monotypy), with labels: handwritten (Staudinger hand) on white paper "Infans / Stgr.", handwritten on yellow paper "Amasia m.[ihi]", printed on pink paper "Origin." and small hand-written "25/7", coll. Staudinger (MNHB). Genitalia slide: G. Deschka 1979 (without name and number on labels) (MNHB).

Since the external appearance of the holotype corresponds perfectly with a photograph of *B. centaureae* as well as the

genitalic structures do (fig. 9), there is no doubt as to the identity of *B. infans* with *B. centaureae*.

Bucculatrix oppositella Staudinger, 1880

Holotype ♂ (by monotypy), with labels: handwritten (Staudinger hand) on white paper "Oppositella Stgr.", handwritten on yellow paper "Amasia m.[ihi]", printed on pink paper "Origin." and small handwritten "10/5", coll. Staudinger (MNHB). Genitalia slide: G. Deschka 1979 (without name and number on the labels, genitalia armature lacking) (MNHB).

The only known type specimen designated here as holotype by monotypy. There is no record of other specimens in the literature.

At a first glance, the holotype looks like a specimen of *B. albella* Stainton, 1867. The colour of head and thorax and the forewing pattern correspond quite well with the characters of *B. albella*.

However, the lacking abdomen of the holotype makes it impossible to decide finally about the status of *B. oppositella*. New material of *Bucculatrix* from the region of Amasya would be helpful to clarify the identity of the species.

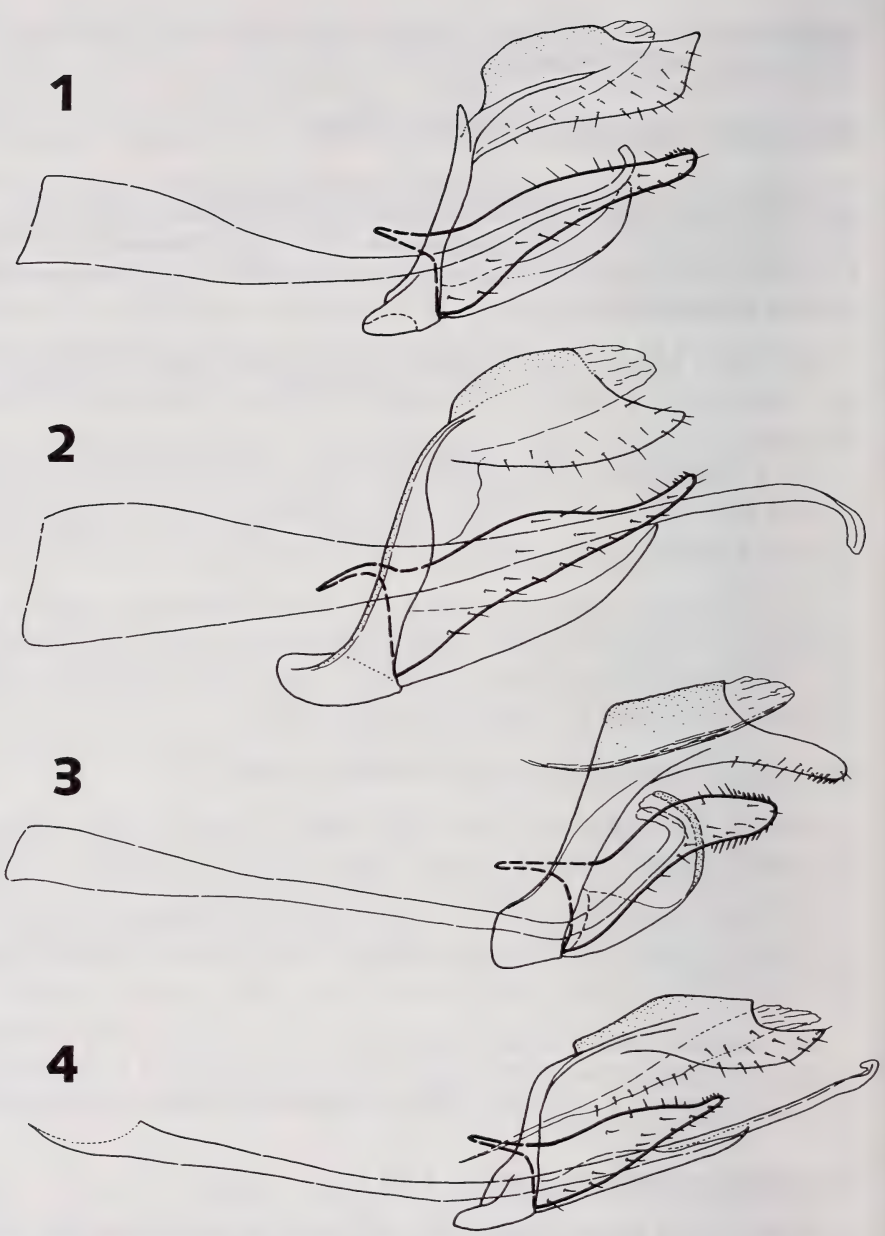
Bucculatrix rhamniella Herrich-Schäffer, [1855]

Lectotype ♀ (designated here), with labels: printed on white paper "H.[errich]-Sch.[äffer]" and on pink paper "Origin.", coll. Herrich-Schäffer, in coll. Staudinger; "Eukitt Präparat Nr. 915" / G. Deschka", designated with printed label on red paper "Lectotypus"(MNHB). Paralectotype (sex unknown; left-side fore- and hindwings only, head, thorax and abdomen lost) with same printed labels as lectotype (MNHB).

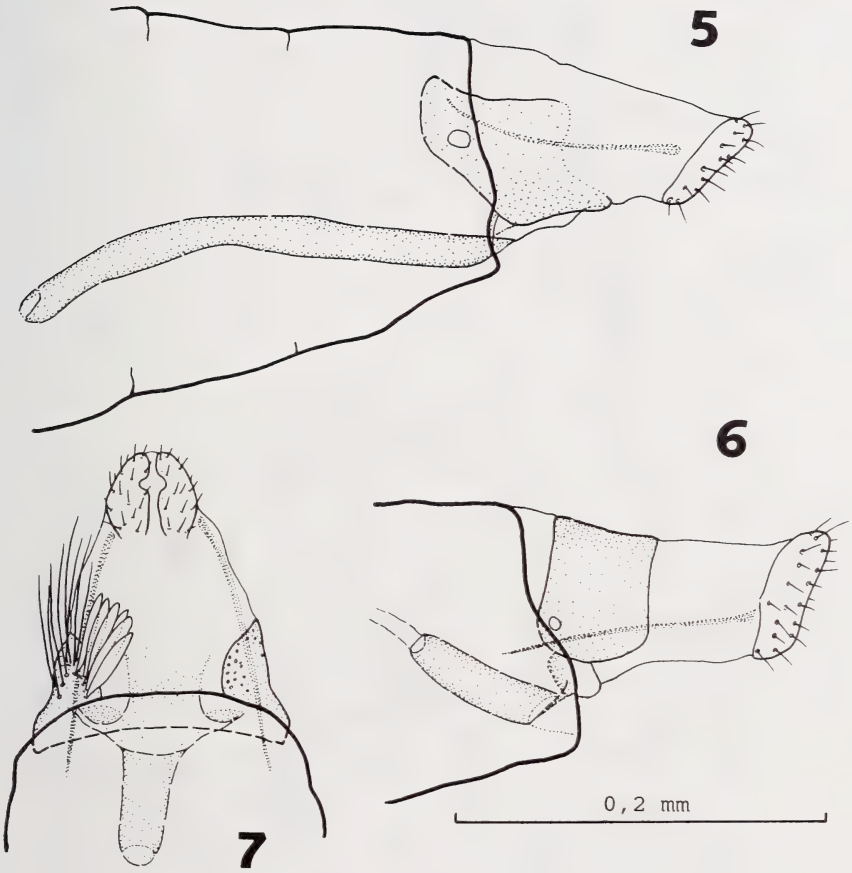
The species was recently redescribed by Buszko (1992). His figures fit perfectly with the traits of the lectotype and its genitalic preparation. So, I can resign from producing a new illustration.

Bucculatrix ulmifoliae Hering, 1931 (figs. 14, 15)

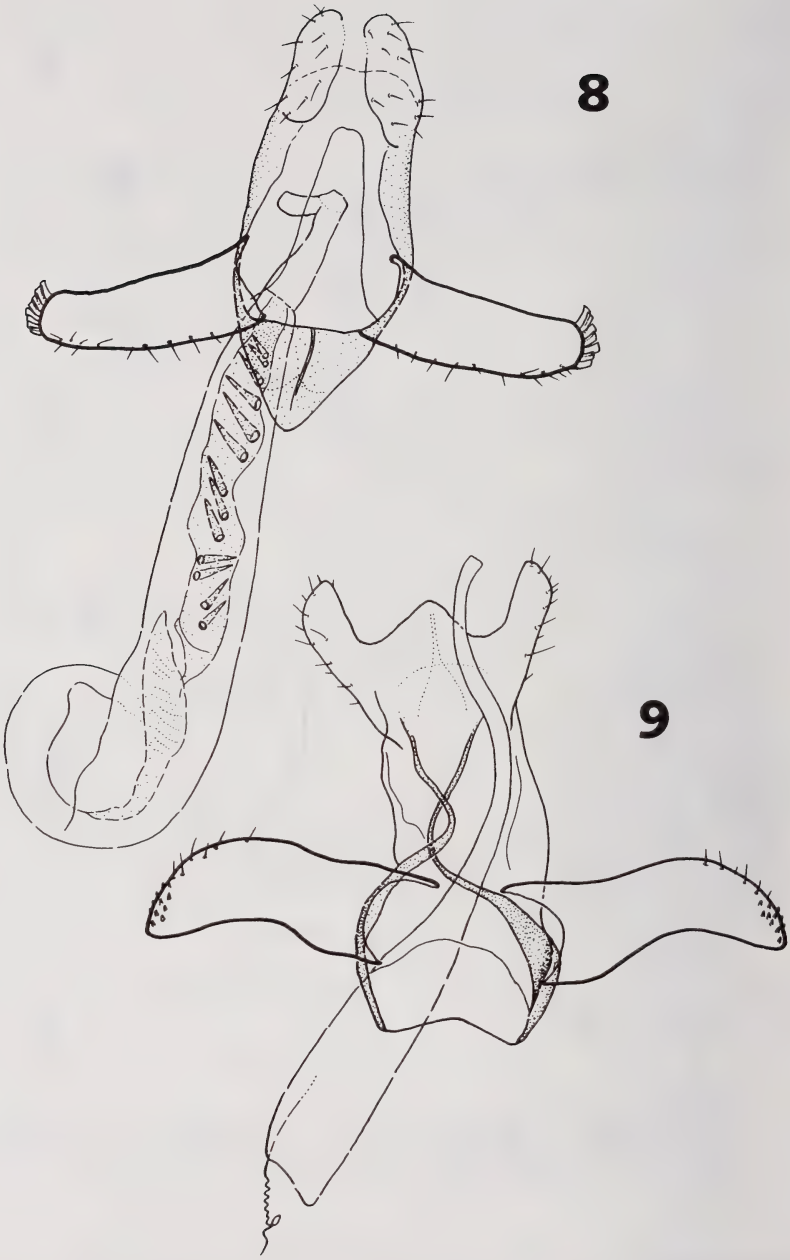
Lectotype ♂ (H. Patzak designated here) with labels: printed on white paper with handwritten inscriptions "Crossen a. O. [now in Poland] / *19.VII.1931* / No. 3843 [Zucht] Hering", printed on white paper with handwritten (Hering) inscriptions "Mine an: *Ulmus* / *campestris*" handwritten (Hering) "*Bucculatrix* / *ulmifoliae m.*[*ihi*] ♂ *Type*" on printed form "det. Mart. Hering", printed on green paper "coll. Hypon. / M. Hering", handwritten (Patzak) on white paper in box "Genit. Präp. / ♂ 2678



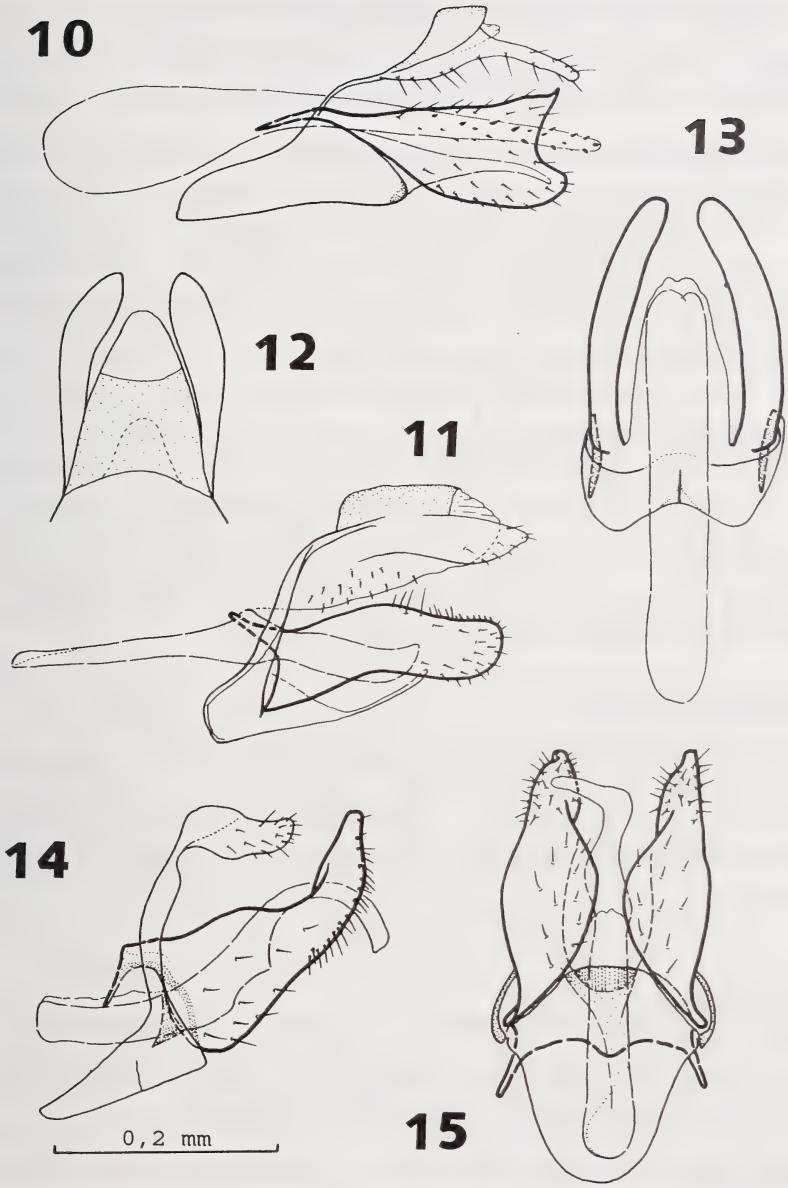
Figs. 1–4. Male genitalia of *Bucculatrix* spp., lateral view: 1 — *B. alpina* Frey, paratype, 2 — *B. argentisignella* H.-S., 3 — *B. atagina* Wke, lectotype, 4 — *B. humiliella* H.-S.



Figs. 5–7. Female genitalia of *Bucculatrix* spp.: 5 — *B. humiliella* H.-S., paratype, 6, 7 — *B. argentisignella* H.-S., paratype (5, 6 — lateral view, 7 — ventral view).



Figs. 8–9. Male genitalia of *Bucculatrix* spp., caudal view: 8 — *B. basifuscella* Stgr., lectotype, 9 — *B. infans* Stgr., lectotype.



Figs. 10–15. Male genitalia of *Bucculatrix* spp.: 10 — *B. demaryella* Dup. (holotype of *B. scoticella* H.-S.), 11–13 — *B. cristatella* Z., 14, 15 — *B. ulmifoliae* Her. (10, 11, 14 — lateral view, 12 — dorsal view, 13, 15 — ventral view).

/ H. Patzak"; designated with a handwritten (Patzak) label on pink paper "Lectotypus / B. ulmifoliae / Patzak desig." (MNHB); Paralectotypes: ♂, same data as lectotype; ♀, Berlin-Karlshorst, 1.6.1930, coll. Hering, genitalia slide: Patzak 2679; ♂, Berlin-Buch, 18.7.1921, Zucht 1827 on *Ulmus campestris*, coll. Hering (all in MNHB).

The genitalic armature of this species is pretty distinctive and sharply different from that of *B. ulmella* Zeller, 1848, which externally is extremely similar to *B. ulmifoliae*. There are no appropriate illustrations of the male genitalia in the literature. The figures in Seksjaeva (1993) are misleading. They probably prevented Puplesis *et al.* (1991) to correctly associate their newly described *Bucculatrix caspica* Puplesis & Sruoga, 1991, reared from *Ulmus carpinifolia* in Southern Russia, with *B. ulmifoliae*. The genitalic armature of both species is remarkably similar. There are only slight differences visible from the original drawings of *B. caspica*. However, they could be regarded as caused by the preparation process. Future studies have to show if *B. caspica* really represents a distinct species. For comparison purposes I give here a figure of the male genitalia (figs. 14, 15) of specimens collected in Potsdam (coll. Hinneberg, MNHB).

Acknowledgements

For the loan or donation of material I would like to express my gratitude to M. Gerstberger, Berlin, Dr. A. Hausmann, München, Dr. P. Huemer, Innsbruck and Mr. K. R. Tuck, London. Helpful comments of P. Huemer are gratefully acknowledged.

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Nota lepid. 22 (3): 227–228; 01.IX.1999 ISSN 0342–7536

Correction to "The life history and ecology of *Euphydryas maturna* (Nymphalidae: Melitaeini) in Finland" by Niklas Wahlberg (in *Nota lepid.* 21 (3): 154–169)

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In the paper "The Life history and ecology of *Euphydryas maturna* (Nymphalidae: Melitaeini) in Finland", Niklas Wahlberg, *Nota Lepid.* 21(3): 15–169, the author incorrectly states that only field observations of caterpillars were taken as evidence of life cycles covering several years in Sweden. In his introduction he writes: "Eliasson (1991) reports a study on *maturna*, in which he suggests a perennial life cycle for the species in Sweden. His evidence is however rather circumstantial". In his discussion he writes: "Eliasson (1991) suggested a two or even three year life cycle as normal for *E. maturna*. The evidence he presents is that there are three size classes of larvae to be found in spring (after diapause)". The true evidence presented in Eliasson (1991) of a triennial life cycle was one brood with hibernations of natural length and one more submitted as the paper was in press. A translation from Swedish of a section in the chapter on the length of development reads: "In one brood from Vs the major part of the caterpillars completed a triennial life cycle (Andersson, pers. comm.; own breeding result 1991). This may be more usual than what has previously been noted, because fewer butterfly collectors care to perform the breeding outdoors. To my knowledge *E. maturna* is the only one out of the Swedish Lepidoptera, leaving aside the wood feeding species, that has been proved to have a triennial life cycle. Contrary to many species with a biennial life cycle no periodicity has evolved. A triennial life cycle means that it hibernates three times, during two summers, only feeding in May, and that the intervals are spent in diapause" (= post-hibernation caterpillars, pre-hibernation instars described in an earlier part of the text).

Eliasson, C., 1991. Study on the occurrence and biology of *Euphydryas maturna* (Lepidoptera: Nymphalidae) in Västmanland (in Swedish with English summary). — *Ent. Tidskr.* 112(4): 113–124.
Stoltze, M., 1996. Danske dagsommerfugle. — Gyllendal, Copenhagen. 383 p.

Nota lepid. 22 (3): 229–232; 01.IX.1999 ISSN 0342–7536

Book reviews • Buchbesprechungen • Analyses

Lafontaine, J. D.: The Moths of America North of Mexico including Greenland. Fascicle 27.3 Noctuoidea. Noctuidae (part). Noctuinae (Part — Noctuini).
28 × 21.5 cm, 348 pp., 36 monochrome plates and 8 colour plates, 130 text figures, mainly distribution maps. Published by The Wedge Entomological Research Foundation, Washington, 1998. ISBN 0-933003-09-9. To be ordered from: The Wedge Entomological Research Foundation, 85253 Ridgetop Drive, Eugene, Oregon 97405, U.S.A. Also obtainable from Apollo Books Aps., Kirkeby Sand 19, DK-5771 Stenstrup, Denmark. Price: Danish Kroner 920, excl. postage.

This is the second part of three fascicles to revise and describe the subfamily Noctuinae in America north of Mexico. The first part (Lafontaine, 1987) was a revision of the genus *Euxoa* in the tribe Agrotini and included 171 species. This part treats 169 species and the remaining part will deal with approximately 130 species, which gives a total of approximately 470 species of Noctuinae. In the European catalogue (Karsholt & Razowski, 1996), 246 Noctuinae are mentioned. Only the genus *Euxoa* consists of 171 American species and only 43 European species. These figures give an impression of the big differences between the faunas of the two regions.

In this comprehensive revision four new genera are proposed: *Prognorisma, Agnorisma, Tesagrotis* and *Parabagrotis*. Furthermore twenty-one new species are described.

In the general introduction to this part the classification of the Noctuoidea is discussed. Lafontaine and Poole (1991) divided the trifid noctuids into two large monophyletic groups, but as this viewpoint has not received general acceptance, the author accordingly has retained the use of Noctuinae as in Karsholt & Razowski (1996) etc. It is a pleasure that the generally accepted classification is used until a new one based on profound scientific research can give a new stable arrangement of genera and species. The general introduction is closed with one key to the genera of Noctuini based on adults and another based on mature larvae.

Each genus is treated the same way. The scientific name followed by the quotation of the primary literary source and the designation of the type species with full reference. All synonyms are listed with full reference and comments when necessary. The general description — which is very accurate — of the genus is followed by one key based on adults and one based on mature larvae, if there are more than one species in the genus.

Each species is treated the same way as for the genera, again with full synonymy and reference. The author is very accurate and he has listed all the known synonyms. As an example, under *Graphiphora augur* (Fabricius, 1775) no less than 26 names are treated with detailed comments on any peculiarity in the case. The following name is worth mentioning: *Rhyacia augur* ab. *striata* Blach Petersen, 1951, Flora Fauna, Silkeborg, 57: 110. Type locality: Gjeding Mose by Arhus, Denmark. This form is described in a small Danish publication by a Danish merchant, who at first started to collect when he retired. Not many Danes know this publication nor the form, which is very rare.

Then the species is described and both similarities and differences with other species are discussed. The larva is described in detail. All known host plants are mentioned and the habits of the species detailed. A description of distribution, biotope and abundance is given. The whole text cannot be praised enough, especially because all doubtful cases are discussed and affinities to Palaearctic sibling species or forms are quoted. This gives the reader a feeling of getting all the known information from the author, making this book quite readable.

The distribution in North America and Greenland is shown on maps for each species. Only data on examined material is plotted on these.

Some of the species treated, especially many of the *Xestia*, occur in Siberia and some also in Europe. It would have been better had the total distribution been shown, as was done by the author in earlier publications by means of "circumpolar" maps.

All species except *Hemipachnobia subporphyrea* (Walker, 1858) are figured in natural size on seven colour plates of high quality. Usually several specimens showing different forms are presented to give an idea about the variation in the species. Many species are only represented by male specimens, and sometimes single specimens overlap others or are cut at the edge of the plate. One more plate could have solved these problems. The last colour plate shows 24 nice pictures of full grown larvae.

On the 36 monochrome plates, again of a very high quality, the male and female genitalia of nearly all species are shown. The adult of the forementioned species and its sibling species is figured on one of the monochrome plates.

Traditionally, American literature does not affect Europeans very much. Only the very professional and semi-professional people buy American literature. This is highly regrettable for two reasons. Only some species are holarctic, but the history of European lepidopterology is full of examples of species, which have been overlooked as being holarctic and hence have been named more than once in history. The other reason is that knowledge of the diversity within a genus in one part of the world can help in a better understanding of this genus in another part of the world. A quick look at the colour plates of this book gives the impression that several species appear hard to distinguish

from European species. On plate two, figures 36 and 37, *Xestia smithii* (Snellen, 1896) is shown. It can only be recognized as distinct by its genitalia. The question remains as to how many holarctic species are still to be found.

To illustrate the affinities between the Nearctic and Palaearctic faunas I will list here some species occurring in both regions.

Palaearctic species accidentally introduced to North America:
Noctua pronuba (Linnaeus, 1758), introduced about 1979 at Halifax, Nova Scotia and now spreading.
Noctua comes (Hübner, 1813), introduced at Vancouver about 1982 and now spreading.
Xestia xanthographa (Denis & Schiffermüller, 1775), introduced several times and now common in the central parts of the West Coast.

Species with a holarctic distribution, mostly occurring in the northern part of the forest zone or in close association to it (8 cases):

Eurois occulta (Linnaeus, 1758), *Graphiphora augur* (Fabricius, 1775), *Anaplectoides prasina* (Denis & Schiffermüller, 1775), *Xestia c-nigrum* (Linnaeus, 1758), *Xestia speciosa* (Hübner, 1813), *Xestia tecta* (Hübner, 1808), *Xestia lorezi* (Staudinger, 1891) and *Xestia atrata* (Morrison, 1874). Last-mentioned species was, until a few years ago, only known after a few specimens found in central Siberia and in spruce forest in North America, but a few specimens have now been found in central Sweden close to the Norwegian border in primary spruce forest.

Species with a holarctic distribution, occurring in coastal regions along the arctic sea (3 cases):

Xestia quieta (Hübner, 1813), *Xestia lyngei* (Rebel, 1923) and *Xestia liquidaria* (Eversmann, 1848).

Species occurring in the nearctic and in central and northern Siberia (12 in total), some of these recorded from the islands of Novaya Zemlaya or from northern Russia (Siberia). The author mentions three species from northern Russia, and it is not the European part but in fact northern Siberia. Most of these species could occur in northern Europe, Russia and the Ural mountains, either or not in isolated populations.

Two of the treated species occur in Greenland, which is of special interest to Danish people.

Rhyacia quadrangula (Zetterstedt, 1839), occurring in southern Greenland, central and eastern Asia and also on Iceland, where it is common. It is also a European species.
Spaelotis clandestina (Harris, 1841), occurring in southern Greenland and mentioned in the European catalogue. This species is now established as different from the north European species *Spaelotis suecica* (Aurivillius, 1890). The whole discussion and the differential diagnosis of the two sibling species is presented in detail in the book.

In the work "The Moths of America North of Mexico" there are now four volumes, that have been published in 1987, 1991, 1995 and the present in 1998. They all represent milestones in the study of the world noctuid fauna. It cannot be welcomed enough that people spend their time and efforts to produce such important works to the benefit of all people interested in studying the diversity of nature.

Knud LARSEN

NOWACKI, Janusz: The Noctuids (Lepidoptera, Noctuidae) of Central Europe. 17 × 23.5 cm, 130 pp., 41 black and white plates, 24 colour plates, hardback. Published by F. Slamka, Bratislava, 1998. ISBN 80-967540-4-1.

After a short introduction, some comments are given on the phylogeny, the general morphology and the different stadia of the Noctuidae. In the systematic part 597 species are described shortly. The systematic order follows the one in Nowacki & Fibiger (1996) with a few exceptions. Every species is treated in the same way: the general distribution and the occurrence are given, the habitat is characterised briefly and the flight period of the adult is given, the foodplant(s) of the caterpillar is listed as well as the best time to search for these larvae. The text part concludes with a list of references and an alphabetic species index (genera are omitted).

The biggest part of this book consists of a series of plates. On 41 black and white plates nearly all male and female genitalia of the described species are given, mainly drawn after earlier publications, and completed with original drawings. Though most of these drawings are clear and sharply printed, some of them are too small to give all the details. The 24 colour plates contain photographs of all described species. Most of these plates are of very good quality. The species are very well recognisable.

The delimitation of the geographical area covered is rather arbitrary, and one may especially regret that the Alps are not included in the present book. Anyway, for the Central European lepidopterist who wants to identify his Noctuid specimens, this book can serve as a valuable tool, taking into account that both male and female genitalia, as well as a photograph of the adult, are at hand.

Guido DE PRINS

Instructions for authors

Manuscripts and all correspondence related to editorial policy should be sent to the editor: Alain Olivier, Lt. Lippenslaan 43, bus 14, B-2140 Antwerpen-Borgerhout, Belgium.

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The authors should strictly follow provisions of the current edition of the *International Code of Zoological Nomenclature*. New taxa must be distinguished from related taxa (diagnosis, key). The abbreviations **gen. n., sp. n., syn. n., comb. n.** should be used to distinguish all new taxa, new synonymies and new combinations. In describing new genus group taxa, the nominal type-species must be designated in its original combination and with reference to the original description immediately after the new name. In describing new species group taxa, one specimen must be designated as the holotype; other specimens mentioned in the original description and included into the type series are to be designated as paratypes — all immediately after the name. The complete data of the holotype and paratypes, and the institutions in which they are deposited (abbreviated as explained in the introductory section), must be recorded in the original description as follows:

Material. Holotype @, Turkey, Hakkari, 8 km E. of Uludere, 1200 m, 10.VI.1984, H. van Oorschot leg. (ITZA). Paratypes: 7@, 3#, labelled as holotype; @, #, "Achalzich Chambobel 1910 Korb" (NHMW); 2@, #, Iraq, Kurdistan, Sersang, 1500 m, L. Higgins leg. (BMNH); @, Iraq, "Shaqlawa, 2500 ft, Kurdistan, 15/24 May 1957" L. G. Higgins leg. (BMNH).

All material examined should be listed in similar format: localities should be cited in order of increasing precision as shown in the examples; in cases when label text is quoted, it should be included between opening and closing inverted commas.

Figures must be drawn in black waterproof ink and should be submitted about twice their printed size, labelled with stencilled or pre-printed lettering or numbering in Arabic numerals large enough to allow reduction. Photographs must be best quality prints on glossy paper. Each drawing, graph or photograph should be signed on the back by the author's name and the fig. (or plate) number; the top should be indicated.

References in the text should be cited by author, date (and page, table, plate, figure if necessary) and should be collated at the end of the paper in alphabetical and then in chronological order in the following form (please draw attention to the punctuation and the use of Em (—) and En (–) dash not replaced with a nonbreaking hyphen (-):

Higgins, L. G., 1950. A descriptive catalogue of the Palaearctic *Euphydryas* (Lepidoptera: Rhopalocera). — *Trans.R.ent.Soc.Lond.* 101: 435–489, figs. 1–44, 7 maps.

Higgins, L. G. & Riley, N. D., 1980. A field guide to the butterflies of Britain and Europe. 4th ed. — Collins, London. 384 p., 63 pls.

Staudinger, O., 1901. Famil. Papilionidae – Hepialidae. *In*: Staudinger, O. & Rebel, H. Catalog der Lepidopteren des palaearctischen Faunengebietes. 3. Aufl. — Friedländer & Sohn, Berlin. XXX+411 p. (Tagfalter p. 1—97).

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The systematic position of the genus *Bagdadia* (Gelechiidae)

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Summary. The systematic position of *Bagdadia* Amsel, 1949 is discussed; one synonymy at generic level (*Capidentalia* Park, 1995, **syn. n.**) and eleven new combinations are established. A lectotype is designated for *Bagdadia irakella* Amsel, 1949, and its male genitalia are illustrated.

Zusammenfassung. Die systematische Stellung von *Bagdadia* Amsel, 1949 wird diskutiert; ein Synonym im Gattungsrang (*Capidentalia* Park, 1995, **syn. n.**) und elf neue Kombinationen werden festgestellt. Ein Lectotypus wird festgelegt für *Bagdadia irakella* Amsel, 1949, und die männlichen Genitalien werden abgebildet.

Résumé. La position systématique de *Bagdadia* Amsel, 1949 est discutée; un synonyme au niveau générique (*Capidentalia* Park, 1995, **syn. n.**) et onze nouvelles combinaisons sont établis. Un lectotype est désigné pour *Bagdadia irakella* Amsel, 1949 et les genitalia mâles sont illustrés.

Key words: Lepidoptera, Gelechiidae, systematics, *Bagdadia*, synonymy, eastern Palaearctic.

Introduction

The gelechiid genus *Bagdadia* Amsel, 1949 has had an unfortunate early history. Originally placed in the family Scythrididae, its description was accompanied by an inaccurate drawing of the wing venation and an illustration of the wrong male genitalia. It is unsurprising, therefore, that the name has remained no more than a catalogue entry. *Bagdadia* was later transferred to the Gelechiidae (Sattler, 1973: 175) after the type-specimens of the type-species, *B. irakella* Amsel, 1949, ex coll. Wiltshire, had been examined and incorporated into the world collection of The Natural History Museum (British Museum [Natural History] — BMNH). A lectotype was selected at that time, but not formally designated, and preparations of the wings and male genitalia were made. As a result, *Bagdadia* was placed near

Hypatima Hübner and other chelariine genera and *'Nothris' salicicolella* Kuznetsov was recognized as being congeneric with *B. irakella*. In the course of more recent studies of Far Eastern Chelariinae, further described and undescribed species were discovered and the genus was described a second time (Park, 1995: 84, as *Capidentalia*).

Bagdadia Amsel, 1949

Bagdadia Amsel, 1949: 321. Type-species: *Bagdadia irakella* Amsel, 1949: 322, pl. 9, fig. 64, pl. 11, figs 78, 79, pl. 12, fig. 99, by original designation and monotypy.
Capidentalia Park, 1995: 84. Type-species: *Hypatima claviformis* Park, 1993: 31, figs 9, 28, 47, 64, by original designation. — **Syn. n.**

Frons evenly convex, ocellus absent. Antenna about ⅔ to ¾ length of forewing, scape without pecten. Proboscis developed, squamose; maxillary palpus probably four-segmented, folded over base of proboscis. Labial palpus recurved, segment 2 with dense sub-triangular tuft beneath, segment 3 as long as 2 or slightly longer, simple, acute. Forewing lanceolate-ovate with complete gelechiid venation. Costa with moderate pterostigma between Sc and R_3; R_{4+5} stalked, R_5 to costa; M_1 at base approximated to R_{4+5}, M_2 at base approximated to M_3; distance (at base) M_3–CuA_1 slightly less than CuA_1–CuA_2. Hindwing subtrapezoid, costa straight, termen weakly concave beneath apex. R_1 present, $Sc+R_1$ to distal third of costa, Rs and M_1 on long common stalk, M_2 strongly curved, at base near M_3, on termen almost equidistant between M_1 and M_2; M_2–CuA_2 separate at base. Male genitalia with uncus articulated at base, tilted dorsad, almost at right angles to body axis.

In the original description the genus *Bagdadia* was associated with the *'Metzneria-Isophrictis-Megacraspedus* relationship', which are undisputed Gelechiidae (Anomologinae), but was placed in the family Scythri[d]idae. That placement followed a concept of Börner (1925–1959), based on the presence or absence of a so-called 'Achselkamm' on the underside of the forewing.

The 'Achselkamm', a more or less extensive group of microtrichia, is the alar part of a wing-locking system and links up with a similar group of microtrichia on the mesepimeron to lock the forewing firmly to the sides of the thorax when the moth takes up its resting position (Sattler, 1991). It is situated on the

underside of the forewing, close to the wing base, where it covers part of the denuded humeral field, i. e. the basal area between the costa, vein Sc and the obsolete humeral cross-vein. The presence or absence of the 'Achselkamm' is closely dependent on the natural resting pose of a particular species, and it should be noted that the Gelechiidae *sensu* Börner comprise taxa with and without an 'Achselkamm'. Although Börner (1939: 1385) himself considered the 'Achselkamm', whose function remained unknown to him, to be of lesser importance and unsuitable for determining family groups, he had made some use of it in his keys and system adopted and variously modified in editions 3 to 8 of *Fauna von Deutschland* (Börner, 1925–1959). In that work he divided the 'Familienreihe Gelechioidea' into the Hyponomeutina and Gelechiina. Whilst the Hyponomeutina coincide more or less with the current Yponomeutoidea but include also the Alucitidae and Pterophoridae, the Gelechiina comprise the Gelechioidea in the current sense plus some Choreutidae. The Gelechiina are divided into only two families, distinguished by the presence (Gelechiidae; illustrated example: *Borkhausenia* Hübner, fig. 667) or absence (Scythrididae; illustrated example: *Coleophora* Hübner, fig. 669) of the 'Achselkamm' (Börner, 1959: 389). In terms of families as they are currently recognized (Karsholt & Razowski, 1996), Börner's Gelechiidae comprise the Ethmiidae, Depressariidae, Elachistidae, Agonoxenidae, Chimabachiidae, Oecophoridae (part.), Momphidae, Autostichidae (Symmocinae), Amphisbatidae, Cosmopterigidae (part.), Gelechiidae (part.) and Choreutidae whilst his Scythrididae comprise the Scythrididae s. str., Oecophoridae (Stathmopodinae), Batrachedridae, Coleophoridae, Cosmopterigidae (part.) and Gelechiidae (part.). From edition 5 onwards the genera *Paltodora* Meyrick, 1894, and *Metzneria* Zeller, 1839, were included in the Scythrididae: Scythridinae (Börner, 1944: 403).

Amsel was unable to ascertain whether *Bagdadia* had an 'Achselkamm' but placed the genus with *Metzneria* and *Isophrictis*, almost certainly on account of the great similarity of the genitalia as illustrated in his fig. 64. In fact, that illustration is erroneous; it has nothing to do with *B. irakella* but depicts probably a *Metzneria* sp. The correct genitalia are described and illustrated below under *B. irakella* (Fig. 3).

The wing drawings accompanying the original description (figs 78, 79) are crude and somewhat inaccurate with regard to the wing shape and proportions. For example, the hindwing tornus is less pronounced than illustrated. Moreover, a key character, 'the striking venation of the hindwing' (fig. 79) is a misinterpretation. The stalked veins labelled 'r_1' and 'rr' (=Rs) are in fact Rs and M_1 respectively, as one would expect. In the Gelechiidae vein R_1, if present, leaves Rs at about the basal third where it anostomoses with Sc; the first vein to reach the costa is therefore always Sc+R_1. That anastomosis of R_1 with Sc is clearly present in *Bagdadia* but was overlooked by Amsel; the apparent connection of Rs and Sc in his fig. 79 is a line irregularity in the original drawing. Vein 'm_1' is merely the median fold; it cannot be a true vein because it extends all the way from the base of the wing to the termen, across the discocellular vein, whereas in Gelechiidae the media is never present as a tubular vein in the cell.

The morphological structure, in particular that of abdominal sternite II and the male genitalia, indicates that *Bagdadia* is misplaced in Anomologinae and must be transferred to Chelariinae. In that subfamily the specialized articulated uncus places *Bagdadia* as a senior synonym of *Capidentalia* Park (**syn. n.**). In view of the great confusion in the original description, the incorrect family association, wrong genitalia and misinterpreted wing venation, it would seem forgivable that *Bagdadia* has been ignored in recent studies of chelariine Gelechiidae. However, the genus, its type species, *B. irakella*, and a second species, *B. salicicolella* (Kuznetsov), have been correctly associated with chelariine genera in the BMNH collection for over 30 years. Although Park has otherwise made extensive use of the BMNH collection, he seems to have overlooked *Bagdadia* when describing *Capidentalia*.

Biology. Host plants: unknown for all but three species. *Salix* (Salicaceae) (two species), *Sapota* (Sapotaceae) (one species).

Distribution. Iraq, central Asia, China, Russian Far East, Korea, Japan, Taiwan, Vietnam, India, Sri Lanka, Andaman Islands, Indonesia (Java), South Africa. A record for South America (Ponomarenko, 1997: 49) is in error (Ponomarenko, pers. comm.).

Checklist
Bagdadia Amsel, 1949
Capidentalia Park, 1995, **syn. n.**

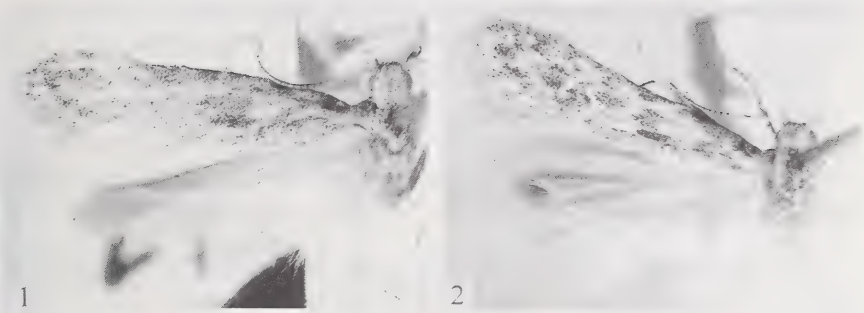
B. claviformis (Park, 1993) (*Hypatima*) **comb. n.**
B. cymoptila (Meyrick, 1929) (*Chelaria*) **comb. n.**
B. eucalla (Li & Zheng, 1998) (*Capidentalia*) **comb. n.**
B. gnomia (Ponomarenko, 1995) (*Capidentalia*) **comb. n.**
B. irakella Amsel, 1949 (*Bagdadia*)
B. isosema (Meyrick, 1921) (*Chelaria*) **comb. n.**
B. paroctas (Meyrick, 1913) (*Chelaria*) **comb. n.**
B. salicicola (Park, 1995) (*Capidentalia*) **comb. n.**
B. salicicolella (Kuznetzov, 1960) (*Nothris*) **comb. n.**
B. sapindivora (Clarke, 1958) (*Chelaria*) **comb. n.**
B. tugaella (Ponomarenko, 1995) (*Capidentalia*) **comb. n.**
B. yanglingensis (Li & Zheng, 1998) (*Capidentalia*) **comb. n.**

***Bagdadia irakella* Amsel, 1949**
Bagdadia irakella Amsel, 1949: 322, pl. 9, fig. 64, pl. 11, figs 78, 79, pl. 12, fig. 99. LECTOTYPE ♂, IRAQ: Baghdad, 21.iii.1937 (*Wiltshire*) (genitalia and wing slides nos. 15 800; BMNH), **here designated**.

Genitalia ♂ (Fig. 3). Uncus trapezoid, distal margin truncate, with pair of short spines and three pairs of short to very short stiff setae. Distal part of gnathos hook of ploughshare shape, trailing edge with spines. Valva long, far exceeding uncus, moderately broad, widest at level of uncus, distally rounded. Anellus lobes pointed. Saccus tapered, distally rounded. Aedeagus curved, basal third bulbous, apex pointed.

Genitalia ♀ unknown. The only available female has lost its abdomen.

Remarks. B. irakella was described from three specimens. In the BMNH there are two specimens from Baghdad, labelled 'Typus ♂' and 'Typus ♀' respectively, the latter lacking the abdomen and left-hand wings; the male is here designated as the lectotype. It should be noted that, according to their labels, both specimens were collected on 21.iii., not 31.iii. as stated in the original description. The third specimen, a male from Karbala



Figs 1–2. *Bagdadia irakella* Amsel: 1 — lectotype ♂, BMNH; 2 — paralectotype ♀, BMNH (right-hand wings, image reversed).

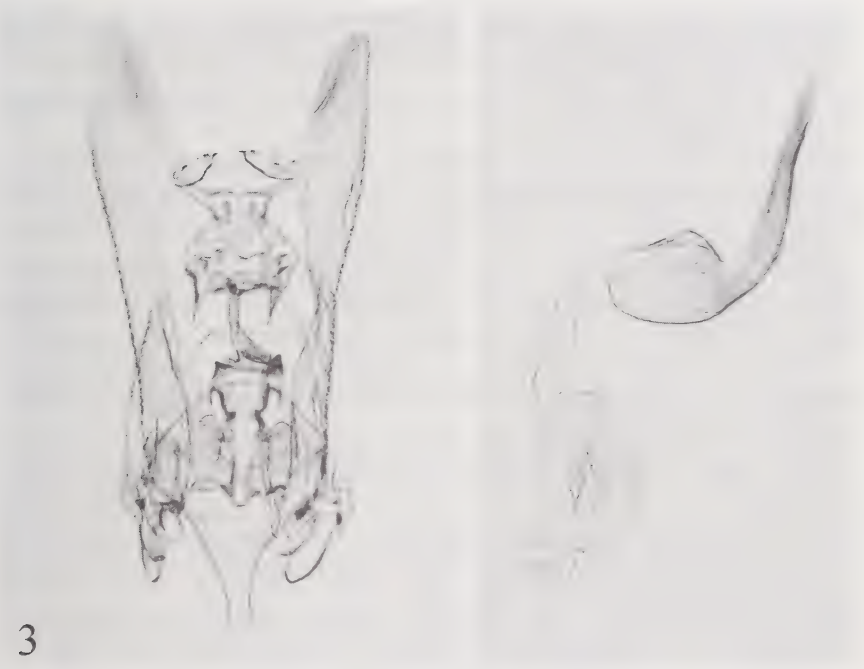


Fig. 3. *Bagdadia irakella* Amsel, lectotype ♂, genitalia slide no. 15 800, BMNH.

desert, is currently not available and presumably is preserved in coll. Amsel, Landessammlungen für Naturkunde, Karlsruhe. It is the specimen from which presumably a genitalia preparation was made although the genitalia illustrated (fig. 64) are probably

those of a *Metzneria* sp. and, in any case, not those of *Bagdadia* (Fig. 3).

Biology unknown. The adults have been collected in March.

Distribution. Iraq (Baghdad; Karbala ['Kerbela'] desert; Gorashala ['Gora Skala']) (Amsel, 1959: 64)).

Acknowledgement

The photomicrographs of the male genitalia were produced by the Photographic Unit, BMNH, those of the adults by Ms M. Vaswani, Department of Entomology, BMNH, London.

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Park, K.-T., 1993. A review of the genus *Hypatima* and its related genera (Lepidoptera, Gelechiidea) in Korea. — *Insecta koreana* 10: 25–49, figs. 1–72.

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In diesen Bestimmungstabellen werden vor allem äussere Merkmale verwendet. Auf Genitalmerkmale wird nur zurückgegriffen, wo äussere Merkmale nicht genügen. Ein zusätzlicher Schlüssel zu den Gattungen auf Grund der männlichen Genitalien ist aber in Arbeit. Das hat bereits zu interessanten Erkenntnissen geführt, der Schlüssel bedarf aber noch einiger Ergänzungen. Wir haben uns deshalb entschlossen, ihn erst im nächsten Teil dieser Arbeit zu publizieren.

Die hier vorgelegten Schlüssel liegen in den Grundzügen schon lange vor. Sie haben von der verzögerten Publikation insofern profitiert, als eine Reihe neuer Erkenntnisse und auch inzwischen beschriebene neue Taxa eingebaut werden konnten. Ferner haben wir uns bemüht, bei anfallenden Bestimmungsarbeiten den Schlüssel immer wieder zu benützen und auch andere damit arbeiten zu lassen. Dabei sind zahlreiche kleine Änderungen eingearbeitet worden, die nützlich sein dürften.

Es zeigt sich schon heute, dass aus den Erkenntnissen beim Erarbeiten der Schlüssel auch einige Änderungen im System abzuleiten sein werden. Im Moment wird jedoch nur eine Änderung vorweggenommen, sie ist in den Schlüsseln bereits eingebaut: Die Tribus Metisini muss von den Oiceticinae abgetrennt und als eigene Unterfamilie betrachtet werden. Die Begründung wird im nächsten Teil der Arbeit im Zusammenhang mit dem Genitalschlüssel erfolgen.

In Karsholt & Razowski (1996) sind die Gattungen *Eumasia* Chrétien und *Pygmaeotinea* Amsel durch die Editoren an die Tribus Apteronini angeschlossen worden. Dies erfolgte ohne unsere Zustimmung und ist sicher nicht berechtigt. Die Stellung von *Eumasia* innerhalb der Psychidae bleibt abzuklären, ebenso diejenige von *Pygmaeotinea*, welche wir bisher nicht selber untersuchen konnten und die wir nach der Beschreibung nicht als Psychide auffassen möchten. Darauf soll in einem letzten Teil der Arbeit später genauer eingegangen werden.

Nomenklatorische Berichtigungen und Ergänzungen zur Liste der palaearktischen Psychidae in Teil 1.

In der Zwischenzeit haben sich einige Korrekturen und Zusätze ergeben. Erstere beruhen vor allem auf der Arbeit von Nye & Fletcher (1991), die uns bei der Drucklegung des ersten Teils noch nicht zugänglich war. Danach sind folgende nomenklatorische Berichtigungen notwendig:

Diplodoma laichartingella: Die gültige Beschreibung von *marginepunctella* Stephens datiert von 1835, diejenige von Stephens 1829 ist nomen nudum).

Dahlica: Typus *D. larviformis* Enderlein, 1912. Nach Stys 1960 ist der Typus dieser Art, ein Weibchen, verschollen. Die Abb. bei Enderlein zeigt ein Tier mit fünfgliedrigen Tarsen, was, zusammen mit der Herkunft („Umgebung von Berlin") am ehesten auf *triquetrella* Hübner schliessen lässt. Auf eine formelle Synonymisierung muss aber vorerst verzichtet werden.

Taleporiinae: Der Autor ist Herrich-Schäffer, 1857.

Taleporiini: ebenfalls Herrich-Schäffer, 1857.

Placodoma: als Synonym beifügen: *Schediastis* Meyrick, 1921.

P. palaestinella: syn.: *epiphracta* Meyrick, 1921.

Melasina: *Typhonia* Boisduval, 1834 (Typus: *Bombyx lugubris* Hübner, [1808]) hat Vorrang vor *Melasina* Boisduval, 1840. Beide haben subjektiv den gleichen Typus.

Dissoctena ochraceella: Rebel in Zerny, 1935.

Dissoctena ellisoni: Rebel in Zerny, 1935.

Psychinae: Boisduval, 1840 (nicht 1829).

Psychini: ebenso.

Bruandia Tutt, 1900 ist ein jüngeres Homonym und damit nicht verfügbar. Als subjektiver Ersatzname wäre *Anaproutia* Lewin, 1949, Typus: *norvegica* Heylaerts, verfügbar, doch wird die Gattung in Zukunft wohl mit *Proutia* oder *Psyche* Schrank vereinigt werden müssen.

Bruandia norvegica: Schöyen, 1880 ist nomen nudum, die gültige Beschreibung stammt von Heylaerts, 1882.

Atelopsyche: Richtige Schreibweise: *Atelopsycha*.

Epichnopteryginae: richtige Schreibweise Epichnopteriginae.

Epichnopterygini: ebenso: Epichnopterigini.

Bijugis Heylaerts, 1879 (der Name wurde von Heylaerts 1881 nochmals aufgestellt).

Epichnopterix: Hübner, 1816 (nicht 1825).

Epichnopterix siederi Agenjo, 1966 ist als nomen nudum zu streichen.

Oiketicinae Herrich-Schäffer 1855 (nicht 1850).

Brachycyttarus Hampson, 1892 (nicht 1893).

Pteroma Hampson, 1892 (nicht 1893). de Freina 1993 stellt *Brachycyttarus* als Synonym hieher, seine Geäderabbildungen stimmen aber mit unseren Untersuchungsergebnissen (siehe Bestimmungstabelle der Männchen, Punkt 142), welche ihrerseits die Angaben von Dierl 1971 voll bestätigen, überhaupt nicht überein, sodass wir seiner Argumentation nicht folgen können.

Amicta: nach de Freina 1989 sind *acutella* Krüger, 1939, *caliginosa* Krüger, 1939, und *syrtana* Krüger, 1939 synonym zu *maliarda* Krüger, 1936. Es wurden allerdings keine Typen untersucht, die Synonymisierung erfolgte auf Grund der kärglichen Urbeschreibungen. Uns lagen diese Arten nicht vor.

Oiketicoides: *Amictoides* Gerasimov, 1937 ist invalid; beifügen: *Amictoides* Bourgogne, 1949; *Paramictoides* Koçak, 1980.

Manatha: Moore, 1877 (nicht 1872); Typus ist *M. albipes* Moore, 1877 (nicht palaearktisch).

Pachythelia: Typus ist *Penthophera nigricans* Curtis, 1828

Auchmophila Rebel, 1906 (nicht 1907).

Aspina: Kozhanchikov, 1960 (nicht 1956). Ein jüngeres Homonym und damit nicht verfügbar, kein objektiver Ersatzname vorhanden; *luteiventris* Kozhanchikov, 1960 (nicht 1956). Die Art lag uns bisher noch nicht vor. Da wir uns auch über die Stellung dieser Gattung nicht ganz im Klaren sind, sehen wir davon ab, jetzt schon einen Ersatznamen aufzustellen.
Lepidoscioptera: Gültiger Name ist *Leptopterix* Hübner, 1816 (nicht 1827).
Phalacropterygini: recte Phalacropterigini
Phalacropterix: Hübner, 1816 (nicht 1825).
Sterrhopterix: Hübner, 1816 (nicht 1825).

Ferner sind folgende Ergänzungen zur Liste 1991 nachzutragen:

Diplodoma samurica Zagulajev, 1992	V: Dagestan
Diplodoma talgica Zagulajev, 1993	R
Narycia maschukella Zagulajev, 1994	R: Pjatigorsk
Narycia tarkitavica Zagulajev, 1993	V: Dagestan
Eosolenobia suifunella (Christoph, 1881)	O: Amur, Ussuri
Dahlica kurentzovi (Solyanikov, 1990)	O: Maritime Territory
Dahlica maritimella (Solyanikov, 1990)	O: Maritime Territory
Dahlica modestella (Solyanikov, 1990)	O: Maritime Territory
Dahlica dubatolovi (Solyanikov, 1990)	S: Yakutsk
Dahlica karadagica (Zagulajev, 1992)	R: Ukraine Krim
Dahlica samurensis (Zagulajev, 1993)	V: Dagestan
Dahlica pallidella (Zagulajev, 1997) **comb.nov.**	R: Krasnodar
Siederia sazonovi (Solyanikov, 1990)	Z: Kirgizstan
Siederia kopetdagica (Zagulajev, 1992)	Z: Turkmenistan
Siederia turkestanica Weidlich, 1996	Z: Uzbekistan
Brevantennia herrmanni Weidlich, 1996	B: Ungarn
Taleporia actatopis Meyrick, 1936	V: Irak
Taleporia isozopha Meyrick, 1936	C
Taleporia euxina Zagulajev, 1997	V: Gelendzhik, Betta
Pseudobankesia casaella Hättenschwiler, 1994	W: Pyrenäen
Pseudobankesia leleupiella Henderickx, 1997	I: Westpyrenäen
Pseudobankesia hauseriella Henderickx, 1998	B: Kreta
Sciopetris karsholti Hättenschwiler, 1996	A: Tunesien
Kozhantshikovia borisi Solyanikov, 1990	O: Ussuri
Luffia gomerensis Henderickx, 1996	A: Gomera (Canar.)
Bruandia caucasica (Solyanikov, 1991) **comb.nov.**	V: Armenien
Bruandia talgarica (Solyanikov, 1991) **comb.nov.**	Z: Trans-Ili Alatau
Bruandia tshatkalica (Solyanikov, 1991) **comb.nov.**	Z: Chatkal Gebirge
Psyche baikalensis (Raigorodskaia, 1965) **comb.nov.**	S: Irkutsk
Psyche bundeli (Solyanikov, 1995) **comb.nov.**	Z: Kirgizstan
Psyche ghilarovi (Solyanikov, 1991) **comb.nov.**	V: Armenien
Psyche hissarica (Solyanikov, 1993) **comb.nov.**	Z: Tadschikistan
Peloponnesia haettenschwileri Hauser, 1996	B: Kreta

Bijugis alba Solyanikov, 1990,	R: Estland
Reisseronia sg. *Tsikalasia* Hauser, 1996	
T. (Tsikalasia) malickyi Hauser, 1996	B: Kreta
Montanima aurea Hättenschwiler, 1996	S: Altai
Psychidopsis saridzhazi Solyanikov, 1993	Z: Terskei-Alatau
Oketicoides saurica Solyanikov, 1997	Z: Kazakhstan
Acanthopsyche apsheronica Solyanikov, 1993	V: Azerbaidjan
Acanthopsyche murzini Solyanikov, 1993	S: Gornyi Altai
Acanthopsyche monticola Solyanikov, 1993	Z: Uzbekistan
Acanthopsyche tzvetaevi Solyanikov, 1996	Z: Uzbekistan
Acanthopsyche subnigra Solyanikov, 1996	Z: Kazakhstan
Acanthopsyche tshemalica Solyanikov, 1996	Z: Gobi Altai
Pachythelia villosella ssp *quadratica* de Freina, 1983	V
Ptilocephala piae Hättenschwiler, 1996	I
Megalophanes hyalina (Solyanikov, 1993) **comb.nov.**	Z: Uzbekistan
Eumasia libanotica Zagulajev, 1996	V: Beirut
Eumasia communita (Meyrick, 1928)	A: Marokko
Eumasia brunella Hättenschwiler, 1998	I
Genus Solemasia Zagulajev, 1996	
Solemasia araxella Zagulajev, 1996	V: Ordubad

Zum Gebrauch der Schlüssel

Geädermerkmale unterliegen bei den Psychiden einer gewissen Variabilität in der Ausbildung einzelner Adern, auch sind die Anhangszellen wie die eingeschobenen Zellen manchmal schlecht zu sehen, wenn eine begrenzende Ader nur schwach ausgebildet ist. Es empfiehlt sich deshalb, das Geäder notfalls am entschuppten Flügel zu verifizieren, auch sollten wenn möglich mehrere Exemplare einer Art, mindestens aber die Flügel beider Körperseiten kontrolliert werden. Genitalmerkmale sind im Schlüssel für die Männchen nur dort verwendet, wo es unumgänglich war. Angaben zu den Weibchen sind in diesem Schlüssel nur als manchmal erwünschte Ergänzung beigegeben.

Im Schlüssel für die Weibchen werden auch Puppenmerkmale mit verwendet, da mindestens die ungeflügelten Weibchen ja meist aus der Puppe gezogen oder auf dem Sack sitzend gefunden werden. Trotzdem kann der Schlüssel verschiedentlich nicht bis zu den Gattungen geführt werden.

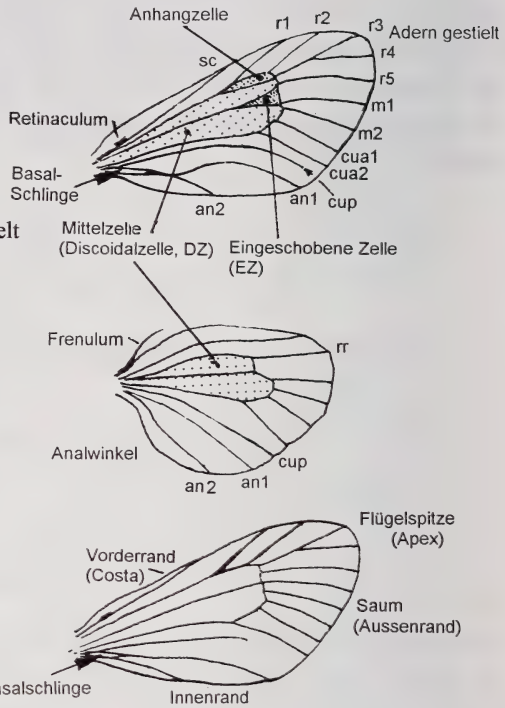
Der Schlüssel für Puppen ist als Hilfe bei der Bestimmung gefundener leerer Säcke, bei denen die Exuvie noch vorhanden ist, gedacht. Er führt je nach Geschlecht und je nach Gattung

verschieden weit und wird sich zweifellos mit weiterer Erfahrung noch verbessern lassen.

Schliesslich folgt eine Merkmals-Matrix für alle Gattungen mit Merkmalen beider Geschlechter, die uns oft gute Dienste geleistet hat und deshalb hier als Ergänzung wiedergegeben werden soll. Sie dient als Überblick, kann aber auch als Bestimmungshilfe, die den Einstieg über ein beliebiges Merkmal erlaubt, benutzt werden.

Schlüssel für Männchen. (Bis Gattung)
(z.T. mit ergänzenden Merkmalen der Weibchen und Säcke)

Verwendete Abkürzungen:
AHZ = Anhangzelle
an = Analader
Ant = Antennen
cua = Cubitus anterior
cup = Cubitus posterior
dkz = doppelkammzähnig
DZ = Discoidalzelle (Mittelzelle)
DZ-Adern = Adern, die frei oder gestielt aus der DZ entspringen, also r1-r5, m1-m3, cua1-2.
Epi = Epiphyse der Vtb
EZ = Eingeschobene Zelle
Fl = Flügel
Hfl = Hinterflügel
Htb = Hintertibia
KZ = Kammzähne
m = Medianader (Media)
Mtb = Mitteltibia
Oc = Ocellen
r = Radialader (Radius)
rr = Radialramus (r2-r5)
sc = Subcosta
Vfl = Vorderflügel
Vtb = Vordertibia



Schlüssel zu den Unterfamilien und Triben.

1) Ant nicht dkz, fadenförmig, oft stark bewimpert oder beborstet (Abb.1b). 2
- Ant dkz (Abb.1a), Oc fehlen (excl. *Atelopsyche*). 5

2) ♂♂ Ant ringsum zerstreut bewimpert, dorsal nur am Glied-Ende mit einem Schuppenkranz, der etwas zahnartig vorspringt. ♀♀ (voll geflügelt) Ant ringsum nur beschuppt (Abb. 3a+b). Oc fehlen. Vfl ohne AHZ und EZ, mit 7, Hfl mit 5 DZ-Adern. ***Eumasia***
- ♂♂ Ant dorsal beschuppt, nur ventral bewimpert (Abb. 2a,11,12). (nur bei *Sciopetris karsholti* ringsum bewimpert, aber auch ohne den dorsalen Schuppenkranz: Abb.2b). Vfl 8-10 DZ-Adern. 3

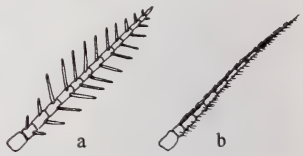


Abb.1: ♂ Fühler, a = doppelkammzähnig, b = fadenförmig.

3) ♂♂ Ant quadrifasciculat, die vier Wimpernbüschel sitzen je auf einem kurzen Zahn (Abb.2a). Oc fehlen. Vtb mit grosser Epi. Vfl mit AHZ und EZ, mit 9, Hfl mit 6 DZ-Adern. **Placodominae** 60
- ♂♂ Ant ventral zerstreut bewimpert, selten Wimpern in 1 oder 2 Kränzen angeordnet. 4

4) Aedeagus meist stark gebogen, mit Stützstab (Abb.4). Oc fehlen (excl. *Diplodoma*, deren Epi aus einem Borstenbüschel besteht). ♀♀ geflügelt oder ungeflügelt. **Naryciinae** 11
- Aedeagus gestreckt oder leicht gebogen, ohne Stützstab (Abb.5). Oc meist vorhanden (excl. *Altobankesia, Kozhantshikovia, Sciopetris karsholti* und *Solemasia*). Epi klein bis fehlend (gut entwickelt bei *Solemasia*). **Taleporiinae** 12

5) Vfl Analadern nach Bildung der Analschlinge wieder divergierend und getrennt in den Saum mündend (Abb.6). Mtb und Htb ohne Sporne (höchstens zwei kleine Endsporne). 6
- Vfl Analadern nach der Schlinge bis zum Saum verschmolzen (Abb.7). Sporne an Mtb und Htb vorhanden. 7

6) (Meist) grosse, kräftige Falter, Ant etwa die halbe Vfl-Länge erreichend (excl. die ostpalaearktischen Gattungen *Manatha* und *Mahasena*). Hfl Adern m2 und m3 entspringen kurz gestielt, aus einem Punkt oder leicht getrennt und divergieren gegen den Saum zu. (Abb.9). Mit basalen Fortsätzen (gabel-artig) am 8. Abdominalsternit. (Abb.42+43). **Oiketicinae** 17
- Sehr zierliche, meist kleine Falter. Ostpalaearktisch. Ant etwa ein Drittel der Vfl-Länge. Sack an Faden aufgehängt. Hfl m2 und m3 entspringen getrennt und bleiben parallel bis zum Saum oder vereinigen sich vor Erreichen des Saumes (Abb.10). Ohne basale Fortsätze an 8. Abdominalsternit. Vtb stets mit grosser Epi. **Metisinae** 140

7) Vfl mit 10 DZ-Adern, Hfl mit 6 (*Dissoctena* 5) DZ-Adern. **Typhoniinae** 13
- Vfl mit 8-9, Hfl mit 5 DZ-Adern. 8

8) Vfl mit 9 DZ-Adern, Vfl mit AHZ, (Zelle ist nicht immer deutlich sichtbar). 10
- Vfl mit 8-9 DZ-Adern, Vfl ohne AHZ. 9

Abb.2a: Fühler von *Placodoma oasella*, quadrifasciculat (vier Borstenbündel auf jedem Glied).

Abb.2b: *Sciopetris karsholti* Ausschnitt aus Antenne, Geissel ist ringsum beborstet.

Abb.3a+b: *Eumasia parietariella*, Ausschnitt aus Antenne.
a = ♂♂, b = ♀♀

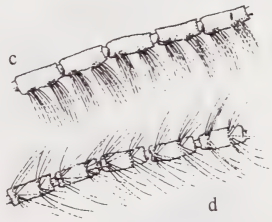


Abb.3c+d: *Solemasia araxella*, Ausschnitt aus Antenne c = lateral und d = ventral, die Beborstung besteht aus zwei Kränzen pro Glied (dorsal beschuppt ?).
(nach ZAGULAJEV, 1996).

9) Fl Schuppen einspitzig (Abb.18) oder gemischt mit kurzen, breiten, mehrspitzigen Schuppen (Abb.17). Ant KZ unbeschuppt oder nur mit einzelnen feinen, einspitzigen Schuppen besetzt. (*Psychidopsis* und *Psychocentra* ?). Vfl meist mit EZ (excl. *Psychidopsis*). **Epichnopteriginae** 16

- Fl Schuppen meist breit, immer mehrspitzig (Abb.17). Ant KZ meist beschuppt, Vfl mit oder ohne EZ. **Psychinae** 15

10) Labialpalpen 3-gliedrig, Körper kräftig. **Typhoniinae** 13
(Tribus Dissoctenioidini und Genus *Penestoglossa*)

- Labialpalpen rudimentär, auf ein Glied reduziert. Zierliche Falterchen mit zartem Körper. **Psychinae** 15

Abb.4: Aedeagus von *Dahlica triquetrella*.

Abb.5: Aedeagus von *Taleporia tubulosa*.

Naryciinae

11) Epi gut sichtbar, aus einem Borstenbüschel bestehend (*Paranarychia* ?). Labialpalpen lang, deutlich 3 Glieder. Vfl 9-10 DZ-Adern. ♀ mit geschlossenem Kranz von Afterwolle. **Naryciini** 20

- Epi nur mikroskopisch sichtbar oder ganz fehlend. Labialpalpen rudimentär. Vfl 9 DZ-Adern. Afterwolle der ♀ nur ventral. **Dahlicini** 30

Abb.6: Aderverlauf im hinteren Teil des Vfl bei Oiketicinae. Analadern sind betont.

Taleporiinae

12) Oc vorhanden, Hfl mit EZ, Vfl ohne AHZ und EZ, ♀♀ geflügelt. **Eotaleporiini** 40

- Oc vorhanden oder fehlend. Vfl oft mit AHZ (fehlt *Solemasia, Kozhantshikovia* und *Sc. karsholti*), Hfl ohne EZ (excl. *S. karsholti*). ♀♀ ungeflügelt. (♀♀ von *Solemasia* und *S. karsholti* unbekannt). **Taleporiini** 50

Abb.7: Aderverlauf im hinteren Teil des Vfl bei mehreren Unterfamilien. Analadern sind betont.

Typhoniinae

13) Vfl mit 9 DZ-Adern (*Eumelasina* 10; soll aber nach KOZHANCHIKOV 1956 2 AHZ haben {?}, Abb.13), KZ unbeschuppt (*Dissoctenioides* ?) Labialpalpen 3 Glieder. 14

Abb.8: Kopf-Brustplatte der Puppe mit Höcker, Pfeil (Tribus Typhoniini).

- Vfl mit 10 DZ-Adern, mit EZ (excl. *Eochorica*). KZ beschuppt. Labialpalpen 1-3 Glieder, kurz, aber mit langem Haarbusch. Puppen Kopfplatte mit Höcker (Abb.8). **Typhoniini** 90

14) Vtb mit grosser Epi. Gesicht angedrückt beschuppt, Labialpalpen nach vorn gerichtet. **Penestoglossini** 70
- Vtb ohne Epi. Gesicht abstehend behaart, Labialpalpen fein. **Dissoctenioidini** 80

Psychinae

15) Vtb ohne Epi. Oc fehlen, KZ beschuppt (*Pseudofumea* ?). **Peloponnesini** 110
- Vtb mit Epi. Oc nur bei *Atelopsyche*, KZ mit oder ohne Schuppen. **Psychini** 100

Epichnopteriginae

16) Labialpalpen sehr lang, 3-gliedrig, Vtb ohne Epi. Vfl 8 DZ-Adern, ohne EZ. Htb nur mit Endspornen. **Stichobasiini** 130
- Labialpalpen rudimentär, Vtb mit oder ohne Epi. Htb mit Mittel- und Endspornen (excl. *Reisseronia*). Vfl (6)-8-9 DZ-Adern, fast stets mit EZ. **Epichnopterigini** 120

Oiketicinae

17) Vtb mit grosser Epi. **Acanthopsychini** 150
- Vtb ohne Epi. 18

18) Vfl mit 9-10, Hfl mit 5-6 DZ-Adern. **Phalacropterigini** 180
(*Aspina* und *Chalioides* schlüsseln hier aus. KOZHANCHIKOV, 1956 stellt sie zur Tribus Acanthopsychini, vergl. Punkt 150).
- Vfl mit 7-8, Hfl mit 3-5 DZ-Adern. 19

19) Vfl mit 7-8, Hfl mit 3-4 DZ-Adern, Hfl sc mit rr völlig verschmolzen. Ant stark gekämmt. die KZ schlank. **Oreopsychini** 170
- Vfl mit 8, Hfl mit 5 DZ-Adern und sc frei. Ant KZ nur im basalen Teil lang, auffällig abgeflacht (Abb. 46). **Apteronini** 190

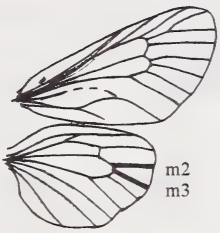


Abb.9: Flügelgeäder von *Acanthopsyche atra*. Der Verlauf von m2 und m3 im Hfl ist betont.

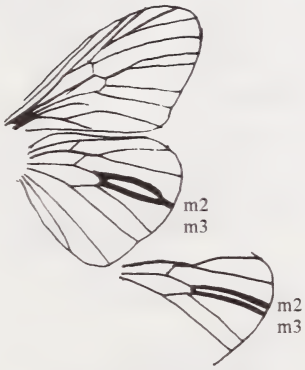


Abb.10: Flügelgeäder der Metisinae : m2 und m3 vereinigen sich oder laufen parallel.

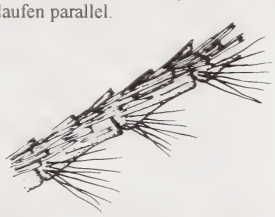


Abb.11: Anordnung der Antennen-Borsten bei *Bankesia*.

Abb.12: Anordnung der Antennen-Borsten bei *Pseudobankesia*.

Schlüssel zu den Gattungen.

Naryciinae
Naryciini

20) ♂ ♀ mit Oc, Vfl 10 DZ-Adern, Hfl mit EZ. ***Diplodoma***
- Oc fehlen, Vfl 9 DZ-Adern, Hfl mit oder ohne EZ. 21

21) Vfl mit AHZ, Hfl ohne EZ, Vtb Epi aus einem Borstenbüschel bestehend. ***Narycia***
- Vfl ohne AHZ, Hfl mit EZ, Vtb Epi sehr klein oder ganz fehlend (Japan, Sibirien, Fernost). ***Paranarychia***

Abb.13: Flügelgeäder von *Eumelasina ardua* KOZH. (nach KOZHANCHIKOV 1956).

Dahlicini

30) Vtb mit Epi (Vorsicht, die Epi sind sehr klein und meist nur im mikroskopischen Präparat sichtbar). ***Siederia***
- Vtb ohne Epi. 31

31) Vfl und Hfl mit EZ. ***Eosolenobia***
- Vfl und Hfl ohne EZ. 32

32) Vfl mit AHZ. 33
- Vfl ohne AHZ. 34

33) ♂ Säcke stark aufgebläht, sehr breit, Breite meistens mehr als die Hälfte der Länge. (♀: Ante- und Postvaginalplatte verschmolzen, Abb.15). ***Praesolenobia***
- ♂ Säcke schmal, 3-5 mal so lang wie breit. (♀: die beiden Platten getrennt, Abb.16). ***Dahlica***

34) Hfl mit 5 DZ-Adern, Flügelspannweite 7-10 mm. (♀ mit langen Ant mit 12-16 Gliedern). ***Postsolenobia***
- Hfl mit 6 DZ-Adern. Flügelspannweite 11-15 mm, (♀ mit kurzen Ant mit 3-10 Gliedern). ***Brevantennia***

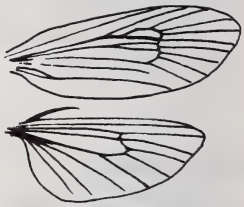


Abb.14: Flügelgeäder von *Penestoglossa dardoinella.*

Abb.15: Genitalplatte des ♀ von *Praesolenobia clathrella* (nach SAUTER 1956).

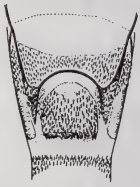


Abb.16: Genitalplatte des ♀ von *Dahlica triquetrella* (nach SAUTER 1956).

Taleporiinae
Eotaleporiini

40) Nur eine Gattung. ***Eotaleporia***

Taleporiini

50) ♂ mit Oc, Vfl 8-10 DZ-Adern. 51
- ♂ und ♀ ohne Oc, Vfl 7-10 DZ-Adern. 54

51) Vfl 8 DZ-Adern, Hfl meist 5, Vfl ohne AHZ, Vtb mit Epi, Ant an der Basis der Glieder mit antero-ventralem Halbkranz von Borsten (wie Abb.11). ***Sciopetris***
- Vfl 9-10 DZ-Adern. 52

52) Vfl 9 DZ-Adern, Hfl 6, Vfl mit AHZ, ♂ Ant mit einem antero-ventralen Halbkranz von Borsten (Abb.11). Vtb ohne Epi. (♀ mit 3 Tarsengliedern). ***Bankesia***
- Vfl 10 DZ-Adern, Hfl 6, Ant ventral gleichmässig bewimpert (Abb.12), Vtb mit oder ohne Epi. (♀ mit 5 Tarsengliedern). 53

53) Hfl mit EZ, Vtb mit gut sichtbarer Epi, Sack 2-3 mal so lang wie breit, weich, häufig mit Teilen von weisslichen Krustenflechten belegt. ***Pseudobankesia***
- Hfl ohne EZ, Vtb mit kaum sichtbarer, da unter den Haaren versteckter Epi, Sack 4-8 mal so lang wie breit, hart, meist ohne Fremdteile. ***Taleporia***

54) Vfl mit AHZ (Nepal). ***Altobankesia***
- Vfl ohne AHZ. 55

55) Hfl mit EZ. Vfl 8, Hfl 6 DZ-Adern. ♂ Ant ringsum unregelmässig bewimpert (Abb.2b), Tunesien. ***"Sciopetris" karsholti***
- Hfl ohne EZ. 56

56) ♂ Ant unten zerstreut beborstet. Vfl 9, Hfl 6 DZ-Adern., Vfl und Hfl mit Y-förmigen Schuppen. Habitus von *Dahlica*. Japan, Sibirien, Fernost. ***Kozhantshikovia***
- ♂ Ant unten Borsten in zwei Querreihen angeordnet (Abb.3c+d), dorsal beschuppt ?. Vfl (nach ZAGULAJEV, 1996) 7, Hfl 5 DZ-Adern Habitus von *Eumasia*. Armenien, Aserbaidschan. ***Solemasia***

(Exemplare aus Westirian: Kermanshah stimmen im Genital sehr gut damit überein, das Geäder aber stark abweichend: Vfl 9, Hfl 6 DZ-Adern. Im Moment ist unklar, wie die Differenz zu deuten ist, die Typen von *Solemasia* haben uns nicht vorgelegen).

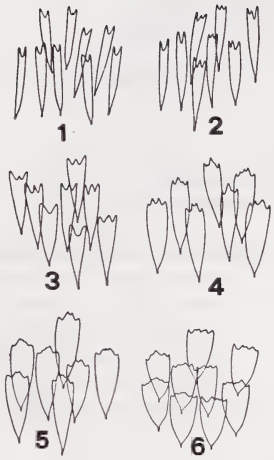


Abb.17: Breiteklassen der zwei- bis mehrspitzigen Schuppen (nach SAUTER 1956).

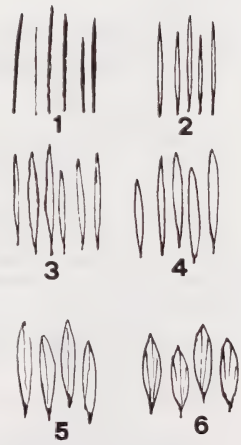


Abb.18: Breiteklassen der einspitzigen Schuppen.

Placodominae
Placodomini

60) Nur eine Gattung. ***Placodoma***

Typhoniinae
Penestoglossini

70) Vfl mit 10 DZ-Adern (nach KOZHANCHIKOV, 1956 mit zwei AHZ ?), ohne EZ, Hfl 6 DZ-Adern (Abb.13). Aedeagus hufeisenförmig gebogen. (♀ Fl rudimentär). ***Eumelasina***
- Vfl mit 9 DZ-Adern, AHZ und EZ, Hfl mit 5 DZ-Adern (Abb.14). Aedeagus gestreckt. (♀ meist normal geflügelt). ***Penestoglossa***

Dissoctenioidini

80) Nur eine Gattung. ***Dissoctenioides***

Typhoniini

90) Vtb mit Epi. (♀ geflügelt oder ungeflügelt). 91
- Vtb ohne Epi. (♀ ungeflügelt). 92

91) Vfl mit AHZ und EZ. 93
- Vfl nur mit AHZ, Vfl cup lang, mündet oft in an. Hfl mit 6 DZ-Adern. (♀ ungeflügelt). ***Eochorica***

(REBEL sagt in der Beschreibung: "Vorderschiene ohne Dorn", alle verglichenen Tiere vom loc. class. haben aber eine lange anliegende Epi. Tiere aus der Typenserie im Wiener Museum haben ebenfalls lange Epi an den Vorderbeinen).

92) Vfl mit EZ und AHZ, Hfl mit 5 DZ-Adern. ***Dissoctena***
- Vfl nur mit EZ, Hfl mit 6 DZ-Adern. ***Melapsyche***

93) Hfl m2 und m3 meistens getrennt, seltener gestielt, Körper robust, cup kurz, äusseres Ende meist frei. (♀ geflügelt). ***Typhonia***
- Hfl m2+m3 gestielt, Körper zierlich, fein. (♀ ungeflügelt). ***Eudissoctena***

Abb.19: Genitalapparat von *Bijugis bombycella.* Die Pfeile zeigen die Einschnürung des Vinculums.

Abb.20: Genitalapparat von *Rebelia* spec.

Abb.21: Genitalapparat von *Montanima karavankensis,* der Aedeagus ist winklig gebogen.

Abb.22: Geäder von *Amicta* spec., die Unterschiede gegenüber *Oiketicoides* sind betont.

Psychinae
Psychini

100) Männchen mit Oc. ***Atelopsyche***
- Ohne Oc. 101

101) Ant KZ kurz, ca. 0.8-1.5 mal so lang wie das Glied, weit getrennt, unbeschuppt, distal verbreitert und abgeflacht. Vfl meist mit AHZ. 102
- Ant KZ lang, ca. 2-4 mal so lang wie das Glied (*B. raiblensis* nur 1.5), eng stehend, distal nicht abgeflacht verbreitert. Ohne AHZ (drei schwierig zu trennende Gattungen). 103

102) Vfl einfarbig dunkel, Hfl m2+m3 und cu1 deutlich und oft weit getrennt (Abb.24). ***Bacotia***
- Vfl hell gegittert, Hfl m2+m3 und cu1 gestielt, wenn auch nur sehr kurz (Abb.25). ***Luffia***

103) Vfl ohne EZ, nicht gegittert, Ant-KZ beschuppt.. ***Psyche***
- Vfl mit EZ. 104

104) Ant KZ meist unbeschuppt (excl. *P. breviserrata*). Vfl mit EZ, ohne Gitterung. ***Proutia***
- Mehr oder weniger deutlich gegittert. Ant KZ unterschiedlich stark beschuppt (*Bruandia raiblensis, norvegica* oder *sichotealinica* KZ kaum beschuppt). ***Bruandia***

Peloponnesiini

110) Vfl mit EZ, Ant mit 14-17 KZ, total 16-21 Glieder. ***Peloponnesia***
- Vfl ohne EZ, Ant mit 13 KZ, total 16 Glieder. ***Pseudofumea***

Epichnopteriginae
Epichnopterigini

120 Vfl mit nur einspitzigen Schuppen der Klassen 1-4 (Abb.18). Htb mit 2 Spornpaaren. 121
- Vfl einspitzige Schuppen der Klassen 1-3 (Abb. 18) durchmengt mit mehrspitzigen Schuppen der Klassen 2-4 (Abb.17). Htb nur mit Endspornpaar. Kleine, dunkle Falterchen bis etwa 10 mm Fl-Spannweite. ***Reisseronia***

Abb.23: Geäder von *Manatha albipes* (nach DIERL 1971).

Abb.24: Hfl-Geäder von *Bacotia* spec.

Abb.25: Hfl-Geäder von *Luffia* spec.

Abb.26: Geäder von *Oiketicoides* spec.

Abb.27: Geäder von *Mahasena yuna*, (nach CHAO 1982).

121) Vtb mit Epi. 122
- Vtb ohne Epi. 127

122) Vfl mit 9 Adern aus DZ, r3 und r4 gestielt bis aus einem Punkt (*Bijugis* kurz gestielt bis leicht getrennt). 123
- Vfl mit 8 oder weniger DZ-Adern. 126

123) Vfl einspitzige Schuppen (Abb.18) gemischt mit breiteren Schuppen (Abb.17), dunkle Falterchen. Femur und Tibia aller Beine lang, oft abstehend behaart. ***Heliopsychidea***
- Vfl Beschuppung nur einspitzig, Klassen 1-5 (Abb.18). Behaarung der Beine kurz, anliegend oder nur schwach abstehend bei Gattung *Montanima.* 124

124) Genital: Vinculum seitlich eingeschnürt (Abb.19), Intersegmentalhaut zwischen Segment 7 und 8 ohne Bedornung. Fl Farbe meist hell, gelblich, mit mehr oder weniger deutlicher Gitterung (*Bijugis bombycella* ssp. *helvetica, B. pectinella* und einige östliche Arten sind braun bis grau und ohne Gitterung). Säcke mit Grasteilen längs belegt. ***Bijugis***
- Genital: Vinculum seitlich nicht eingeschnürt (Abb.20), Intersegmentalhaut zwischen den Segmenten 7 und 8 mit dorsaler Bedornung. Ohne Gitterung. 125

125) Fl breit, Farbe braun bis blassgrau, oft dunkel. Aedeagus schwach gebogen, Tegumen breit (Abb.20). Säcke nur mit Sand belegt. ***Rebelia***
- Fl schmal, blasse Farbe, hyalin, zarte Falterchen, Aedeagus nahezu rechtwinklig gebogen, Tegumen schmal (Abb.21). Säcke mit Grasteilen längs belegt. (Karawanken bis Griechenland und Russland). ***Montanima***

126) Vfl nur 8 DZ-Adern, ohne EZ. ***Psychidopsis***
- Vfl nur 6 DZ-Adern, Vfl mit EZ. (bis heute nur ein Exemplar einer Art bekannt, *P. millierei* HEYLAERTS). ***Psychocentra***

127) Vfl mit 9 DZ-Adern. 128
- Vfl mit 8 DZ-Adern. 129

128) Augenabstand grösser als Augenhöhe (Abb.40), zarte Falterchen, Fl Fransen weisslich, Labialpalpen so lang wie Augenhöhe. ***Psychidea***

Abb.28: Geäder von *Eumeta cramerii,* die EZ sind sehr lang.

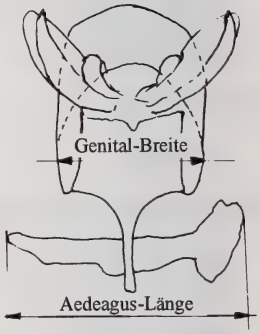


Abb.29: Genitalapparat von *Canephora,* Aedeagus lang mit Wulst am distalen Ende (rechts).

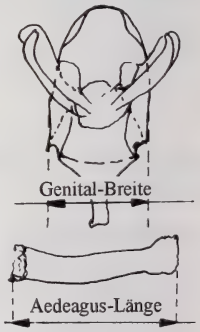


Abb.30: Genital von *Acanthopsyche atra,* langer Aedeagus, ohne Wulst.

- Augenabstand gleich oder kleiner als Augenhöhe (Abb.39), zarte Falterchen, Fl-Fransen weiss, Labialpalpen etwa halb so lang wie Augenhöhe. ***Acentra***

129) Mittelgrosse Falterchen mit 12-18 mm Fl-Spannweite (nur *E. ardua* 8-12 mm), dunkle, schwarzbraune Färbung, ohne Zeichnung oder Gitterung. ***Epichnopterix***
- Kleine Falterchen mit weniger als 12 mm Fl-Spannweite, Fl hell mit dunklen Wellenlinien. ***Whittleia***

Stichobasini

130) Nur eine Gattung. ***Stichobasis***

Metisinae
Metisini

140) Vfl mit 10 DZ-Adern. 141
- Vfl mit 8-9 DZ-Adern. 142

141) Vfl und Hfl mit EZ, Vfl der hintere Teil der DZ ist kürzer und schmaler (Abb.34). ***Metisa***
- Vfl und Hfl ohne EZ, Vfl die DZ ist symmetrisch geteilt (wie Abb.35). ***Eumetisa***

142) Ant KZ beschuppt. Vfl DZ durch den m-Stamm annähernd symmetrisch geteilt, er mündet zwischen m1 und m2 (Abb.35). ***Brachycyttarus***
- Ant KZ unbeschuppt. Vfl DZ durch den m-Stamm asymmetrisch geteilt, er mündet zwischen m3 und cu1 (Abb.36). ***Pteroma***

Oiketicinae
Acanthopsychini

150) Vtb mit Epi. 152
- Vtb ohne Epi. 151

151) Aedeagus etwa so lang wie das gesamte Genital (Südwest-China, Junan Prov. Nur eine Art, *A. luteiventris* KOZHANCHIKOV bekannt). Vfl ohne EZ, Hfl 5 DZ-Adern. ***Aspina***
(Die Gattung *Aspina* kennen wir nicht aus eigener Erfahrung, KOZHANCHIKOV, 1960 stellt sie zur Tribus Acanthopsychini).
- Aedeagus etwas kürzer. Vfl mit grosser EZ, Hfl 6 DZ-Adern. ***Chalioides***

Abb.31: Geäder von *Chaliopsis junodi.*

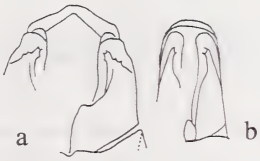


Abb.32: Valve und Tegumen von: a = *Chaliopsis junodi,* b = *Kotochalia shirakii* (nach BOURGOGNE 1990).

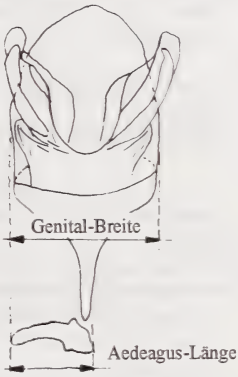


Abb.33: Genital von *Nipponopsyche fuscescens* (nach SEINO 1976). Aedeagus kurz, mit Wulst.

Abb.34: Vorderflügel-Geäder von *Metisa plana,* DZ ist asymmetrisch geteilt.

152) Vfl mit 10 DZ-Adern. 153
- Vfl mit 9 DZ-Adern. 159

153) Vfl ohne EZ. 154
- Vfl mit EZ. 157

154) Ant KZ unbeschuppt. 155
- Ant KZ beschuppt. 156

155) Hfl 6 DZ-Adern, rr mit sc durch Querader verbunden oder kurz anastomosierend (verschmolzen). Vfl cup kräftig gebogen, in an1 mündend (Abb.26), Sack längs belegt. ***Oiketicoides***
- Hfl 4 DZ-Adern, rr durch 1-2 Queradern mit sc verbunden. Vfl cup nicht in an mündend. ***Urobarba***

156) Hfl 6 DZ-Adern, Anastomose zwischen rr und sc ausserhalb der DZ. Geäder wie Abbildung 22, Sack quer belegt. ***Amicta***
- Vfl (8-) 10, Hfl 5-6 DZ-Adern, der vordere Teil der EZ sehr schmal. (Geäder variiert, *M. nigripes* DIERL Vfl 8, Hfl 4 DZ-Adern), Vfl cup kräftig gebogen, in an1 mündend (Abb.23). ***Manatha***

157) Hfl mit 5 DZ-Adern, ohne EZ. Einfarbig, dunkel gefärbt. ***Bambalina***
- Hfl 6 DZ-Adern, mit EZ. 158

158) Kurze EZ im Vfl und Hfl (Abb.27), Ant KZ teilweise beschuppt. (♀ ohne Spitzen auf dem Kopf). ***Mahasena***
- Sehr lange EZ im Vfl und Hfl, oft bis zur Wurzel der Zelle reichend (Abb.28). Ant KZ unbeschuppt, Vfl braun, bei den paläarktischen Arten meist mit auffälligen, creme oder hellbraunen Zeichnungen. (♀ mit 2 sklerotisierten, hornartigen Spitzen auf dem Kopf). ***Eumeta***

159) Vfl und Hfl ohne EZ, Hfl sc und DZ sehr kurz anastomosierend oder mit Querader verbunden. 160
- Vfl und Hfl mit EZ, Hfl sc anastomosiert mit DZ und rr über grosse Länge. 161

160) Hfl 5-6 DZ-Adern, sc mit Querader oder mit kurzer Anastomose im mittleren Teil der DZ. 163
- Hfl 4 DZ-Adern, sc anastomosiert mit dem distalen Teil der DZ. ***Ptilamicta***

Abb.35: Vfl-Geäder von *Brachycyttarus* spec, DZ ist symmetrisch geteilt.

Abb.36: Vfl-Geäder von *Pteroma plagiophleps,* DZ ist asymmetrisch geteilt.

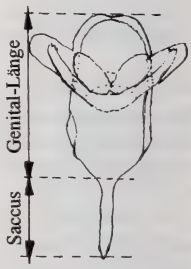


Abb.37: Genital von *Leptopterix hirsutella,* der Saccus ist kurz.

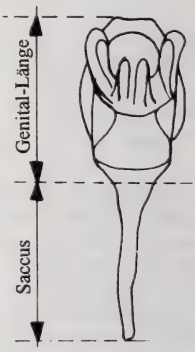


Abb.38: Genital von *Ptilocephala albida,* der Saccus ist lang.

161) Hfl nur 4 DZ-Adern. ***Auchmophila***
- Hfl 5 DZ-Adern, Vfl teilweise mit doppelter EZ (Abb.31). Alle Fl weitgehend unbeschuppt, Fl-Membran glasklar. 162

162) ♂ Genital mit schmaler Valve und gerundetem Tegumen (Abb.32b). Nur eine Art aus Formosa / Taiwan bekannt. ***Kotochalia***
- ♂ Genital mit breiter Valve und eckigem Tegumen (Abb.32a). Vertreter in Südafrika und Vorderasien. ***Chaliopsis***

163) Aedeagus mit auffälligem Wulst am distalen Ende, der mehr als den doppelten Durchmesser des Aedeagus erreicht (Abb.29). 164
- Aedeagus mit kleinerem Wulst (Abb.30), unbeschuppte oder sehr schwach beschuppte KZ. ***Acanthopsyche***

164) Aedeagus länger als Breite des Genitalapparates (Abb.29+30). 165
- Aedeagus kurz, nur etwa die halbe Breite des Genitalapparates erreichend (Abb.33). ***Nipponopsyche***

165) Ant KZ schwach beschuppt, Fl mit breiten, einspitzigen Schuppen der Klassen 5-6 (Abb.18). Flügel dicht beschuppt, undurchsichtig, von dunkler Farbe. ***Canephora***
- Ant KZ meistens unbeschuppt (excl. ssp. *quadratica*). Fl mit schmalen, einspitzigen Schuppen der Klassen 1-3 (Abb.18), Flügel hell, hyalin. ***Pachythelia***

Oreopsychini

170) Vfl mit 7-8 DZ-Adern, Saccus am männlichen Genital nur etwa halb so lang wie der Rest des Genitalapparates (Abb.37). Fl Membran braun oder bräunlich, milchig, nicht transparent. 171
- Vfl mit 7 DZ-Adern, seltener 8, Saccus lang, etwa die Länge des restlichen Genitalapparates erreichend (Abb.38). Robuste Falter, Fl Membran transparent oder leicht milchig getrübt. ***Ptilocephala***

171) Vfl breit, Saum kaum kürzer als Innenrand. Fl Membran milchig-grau, Körper schlank, grau bis gelblich behaart. ***Oreopsyche***

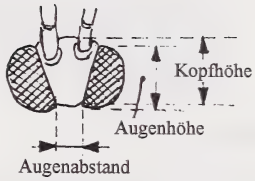


Abb.39: Kopf von *Sterrhopterix fusca* von vorn, die Augenhöhe etwa gleich der Kopfhöhe, Augenabstand klein.

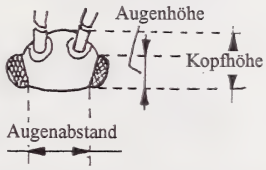


Abb.40: Kopf von *Phalacropterix graminifera* von vorn. Augenhöhe kleiner als Kopfhöhe, Augenabstand gross.

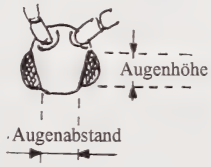


Abb.41: Kopf von *Megalophanes viciella* von vorn, Augenhöhe kleiner als Kopfhöhe, Augenabstand etwa 1-1.5 mal Augenhöhe.

Abb.42: Abdominal-Sternite (links) und Tergite (rechts) von *Megalophanes viciella*.

- Vfl schmal, Saum wesentlich kürzer als der Innenrand. Fl Membran braun oder milchigbraun, Körper robuster, struppig, schwarz behaart. ***Lepidopterix***

Phalacropterigini

180) Hfl sc mit rr lang gestielt, ebenso m2+m3, DZ in beiden Fl sehr breit, Vfl 10 DZ-Adern, r2+r3+r4 gestielt, auch m2+m3 gestielt. Sack breit, kugelig mit quer liegenden Halmen belegt. (Erst aus Tadschikistan bekannt). ***Eopsyche***
- Hfl sc frei oder durch Querader mit rr verbunden. 181

181) Vfl mit 9-10, Hfl mit 6 DZ-Adern. (*P. bruandi* 5-6 DZ-Adern, m2+m3 lang gestielt oder ganz verschmolzen). 182
- Vfl mit 9, Hfl mit 5 DZ-Adern. ***Loebelia***

182) Robuste Falter, Augenabstand 1-2 mal Augenhöhe, Augen kleiner als Kopfhöhe (Abb.40) 183
- Zarte Falter mit breiten Fl und grosser Fl-Fläche, Körper schlank, Augen sehr gross, so hoch wie der Kopf, Abstand kleiner als Augenhöhe (Abb.39). Säcke wirr mit Pflanzenteilen belegt. ***Sterrhopterix***

183) Vfl stark gerundet mit einspitzigen Schuppen der Klassen 1-2 (Abb.18). Ant KZ nur beschuppt, ohne Bewimperung, äusseres Ende meistens deutlich abgeflacht (Abb.44). Abdominalsternite 4-6 T-förmig (Abb.42). Augenabstand etwa 1-1,5 mal Augenhöhe (Abb.40). Sack quer mit runden Grasstücken belegt, ohne äussere Umspinnung. ***Megalophanes***
- Vfl mit spitzem Apex und kurzen, ein- bis mehrspitzigen Schuppen der Klassen 1-2 (Abb.17) und Klassen 2-4 (Abb.18). Ant KZ beschuppt und bewimpert (*P. bruandi* keine oder nur mikroskopisch sichtbare Wimpern), äusseres Ende im Querschnitt rundlich (Abb.45). Abdominalsternite 4-6 drei- oder rechteckig (Abb.43). Augenabstand gegen zwei mal Augenhöhe (Abb.40). Sack quer belegt, mit äusserem Hüllgespinst (*P. praecellens* und *P. graminifera* sind nur schwach umsponnen). ***Phalacropterix***

Apteronini

190) Nur eine Gattung ***Apterona***

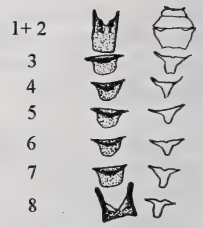


Abb.43: Abdominal-Sternite (links) und Tergite (rechts) von *Phalacropterix apiformis*.

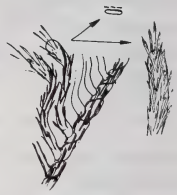


Abb.44: Antenne von *Megalophanes* mit beschuppten Kammzähnen, ohne Bewimperung.
(Nach HÄTTENSCHWILER 1992)

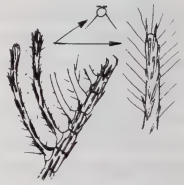


Abb.45: Antenne von *Phalacropterix* mit beschuppten und bewimperten Kammzähnen.
(Nach HÄTTENSCHWILER 1992)

Abb.46: Antenne von *Apterona* spec., die Kammzähne sind deutlich abgeflacht, stark beschuppt, ohne Bewimperung.
a = *Apterona helicoidella* f. *crenulella*
b = *Apterona nylanderi*
(gez. E. TRAUGOTT-OLSEN).

Schlüssel für Weibchen. (Bis Tribus)

1) Voll geflügelt und flugfähig oder mit reduzierten aber noch gut sichtbaren, beschuppten Flügeln. 2
- Ungeflügelt, Flügel auf kaum sichtbare Lappen reduziert oder ganz fehlend. 7

2) Postvaginalplatte mit langen, nach hinten gerichteten Dornen. Antevaginalplatte mit feinen, kurzen und locker stehenden Dornen (Abb.3B) Kopfplatte der Puppe mit 2-3 Borstenpaaren (Abb.1), Puppen Abdominalsegmente mit dorsalen Dornenfeldern (Abb.4A). (Bei Eotaleporiini ist das dorsale Dornenfeld reduziert und oft nur als nach hinten gerichtete Reihe erkennbar). 3
- Postvaginalplatte ohne Dornen, Antevaginalplatte mit dichtem Feld von langen, nach hinten gerichteten Dornen (Abb.3A). Kopfplatte der Puppe mit 4-5 Borstenpaaren (Abb.2), wovon 1-2 auf dem Scheitel; auf mehreren Abdominalsegmenten der Puppen zwei Dornenreihen (Abb.4B). 4

3) Vorderflügel hell und dunkel gezeichnet, Fl Spannweite grösser als 8 mm. Puppen-Kopfplatte mit 2 Borstenpaaren. **Naryciini**
- Vorderflügel einfarbig grau, Fl Spannweite 5-6 mm. Puppen-Kopfplatte mit 3 Borstenpaaren. **Eotaleporiini**

4) Kopfplatte der Puppe mit 5 Borstenpaaren, wovon zwei Paare auf dem Scheitel (Abb. 2), Kopfplatte mit höcker- oder rippenartigem Längswulst zwischen den Ant Ansätzen. Ant oft fein gezähnt. Kräftige Falter mit dunklen, meist einfarbigen oder nur schwach gezeichneten Fl. **Typhoniini, *Typhonia***
- 4 Borstenpaare auf Puppen-Kopfplatte, ohne Wulst. 5

5) Vfl 9-10 DZ-Adern, kräftige Falter, Fl graubraun, oft mit unregelmässig eingestreuten hellen und dunklen Flecken. **Penestoglossini**
- Vfl 7-8, selten 9 Dz-Adern; feine, zierliche Falter, Fl gelb und braun-schwarz gemustert. 6

6) Vfl mit 8-9 DZ-Adern. **Placodomini**
- Vfl mit 7 DZ-Adern, Ant ringsum beschuppt, Scapus mit langem Haarbusch (Abb.6). (incertae sedis). ***Eumasia***

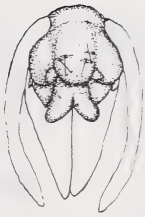


Abb.1: Puppen-Kopfplatte von *P. alpestrella* mit 2 Borstenpaaren (Pfeil).

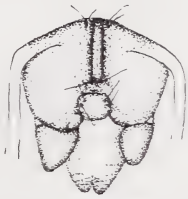


Abb.2: Puppen-Kopfplatte von *Dissoctena granigerella* mit 5 Borstenpaaren, wovon 2 auf dem Scheitel (Pfeil)

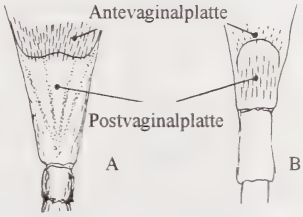


Abb.3: Umgebung der Genitalöffnung der ♀ von:
A = *Typhonia ciliaris,*
B = *Diplodoma laichartingella*

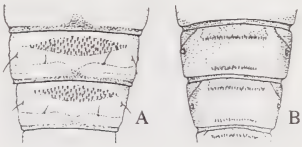


Abb.4: Abdominaltergite der Puppe. A = Dornenfeld, B = Dornenreihen. (Aus: "Pro Natura - Schweizerischer Bund für Naturschutz (Hrsg. 1997) Schmetterlinge und ihre Lebensräume, Bd. 2", gez. W. ETTMÜLLER)

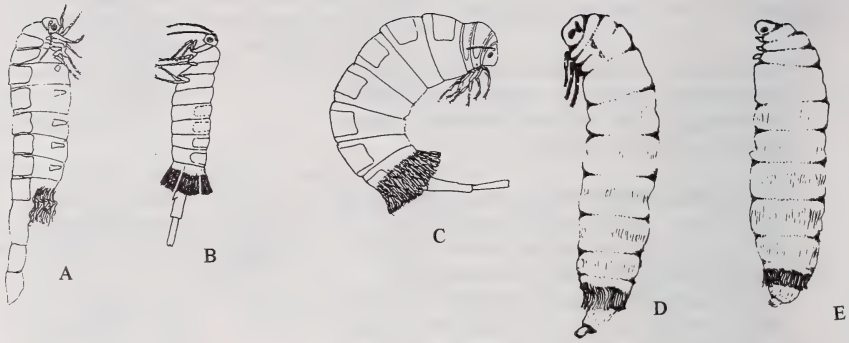


Abb.5: ♀ von: A = Dahlicini, Afterwolle nur ventral am Segment 7, B = Taleporiinae und Typhoniinae, Afterwolle als Kranz um das ganze Abdomen auf Segment 7, C = Psychinae, Kranz auf Segment 7, D = Epichnopteriginae, starker Kranz auf Segment 7 und schwächere Kränze auf den Segmenten 2-6, E = Oiketicinae, Anordnung wie bei D

7) Ant und Beine vorhanden, Gliederung deutlich erkennbar, Zahl der Tarsenglieder oft reduziert, aber meist vollständig. Mit Ausnahme der Epichnopteriginae verlassen sie den Sack zum Anlocken der ♂ und zur Kopula. 8
- Ant und Beine fehlen, oder sind auf kleine Stummel von maximal 2-3 Gliedern reduziert. Das ♀ verlässt den Sack nicht. 16

8) Abdominalsegmente der Puppe mit je einem dorsalen Dornenfeld (Abb.4A), Kopfplatte mit 2 Borstenpaaren. 9
- Abdominalsegmente der Puppe mit meist zwei dorsalen Dornenreihen (Abb.4B), Kopfplatte mit 4-5 Borstenpaaren. 10

9) Afterwolle auf dem Abdominalsegment 7 nur ventral (Abb.5A). **Dahlicini**
- Afterwolle auf dem Abdominalsegment 7 als Kranz rings um den Körper (Abb.5B). **Taleporiini**

10) Puppen-Kopfplatte mit 5 Borstenpaaren, davon zwei Paare auf dem Scheitel (Abb.2). **Typhoniini**
- Puppen-Kopfplatte mit 4 Borstenpaaren, davon ein Paar auf dem Scheitel. 11

11) Legeröhre lang, ausstreckbar, oft so lang wie der restliche Körper, zum Teil stark sklerotisiert. Nur ein Kranz von Afterwolle am 7. Abdominalsegment (Abb.5C). ♀ verlässt den Sack zum Anlocken der ♂ und zur Kopula. (*Pseudofumea* ?). **Psychinae**

Abb.6: Fühlerbasis des ♀ Fühlers von *Eumasia*, rechts Ausschnitt, die Geissel ist ringsum beschuppt

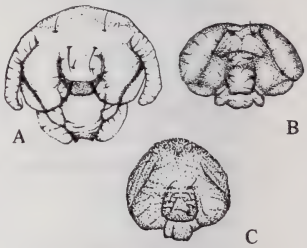


Abb.7: Puppen-Kopfplatten der ♀ von Epichnopteriginae: A = *Rebelia kruegeri*, B = *Epichnopterix plumella*, C = *Stichobasis helicinoides*

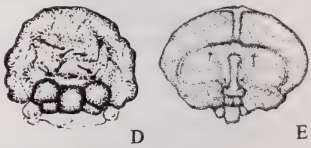


Abb.8: Oiketicinae: D = *Canephora unicolor*, E = *Ptilocephala plumifera*

- Legeröhre kürzer, wenig sklerotisiert, kann kaum oder nicht ausgestreckt werden. Afterwollkränze auf mehreren Abdominalsegmenten (oft abgeschabt und undeutlich sichtbar), wobei der Kranz auf Segment 7 am stärksten ausgebildet ist (Abb.5D, E). ♀ verlassen den Sack nicht, höchstens nach der Eiablage. 12

12) Puppen-Kopfplatte mit deutlich erkennbaren Fühlerscheiden (Abb.7A, B). *Stichobasis* hat schon weitergehende Verwachsungen. (Abb.7C). **Epichnopteriginae**
- Puppen-Kopfplatte stark verwachsen, einzelne Teile wie Fühlerscheiden kaum noch erkennbar (Abb.8D, E). 13

13) Kopf klein, vom Prothorax deutlich überragt und teilweise verdeckt (Abb.9). **Metisinae**
- Kopf vom Prothorax nicht überragt, gut sichtbar (Abb.10). 14

14) Kopf stark vorstehend (Abb.11, 12). 15
- Kopf flach, nicht oder kaum vorstehend (Abb.10). 16

15) Kopf stark nach vorn-unten eingebogen, Körper gestreckt (Abb.11). **Phalacropterigini pp.** ***Sterrhopterix. (Eopsyche ?)***
- Kopf stark nach vorn-unten eingebogen, Körper stark eingekrümmt (Abb.12). **Apteronini**

16) Puppenhülle schwarz, an beiden Enden braun, (*P. apiformis* mindestens schwarze Intersegmentalhäute). **Phalacropterigini pp.**
- Ganze Puppenhülle hellbraun. 17

17) Beine stummelförmig. **Acanthopsychini**
- Beine fehlen ganz oder sind nur noch als Punkte oder kleine, fleischige Zäpfchen erkennbar. (Unterscheidung von voriger Tribus oft schwierig). **Oreopsychini**

Abb.9: Vorderes Körperende der ♀ von: a = *Metisa plana,*
b = *Brachycyttarus fasciatus,*
c = *Pteroma pendula*

Abb.10: Vorderes Körperende des ♀ von *Canephora unicolor*

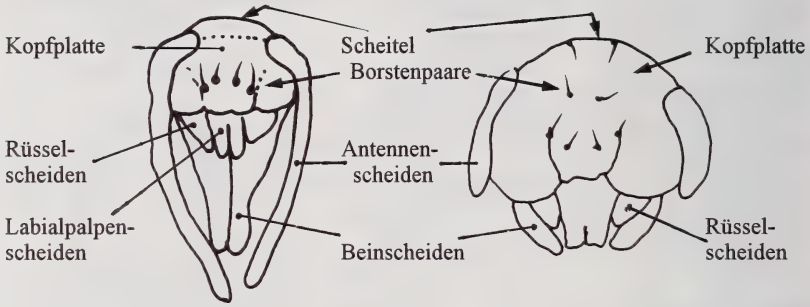
Abb.11: ♀ von *Sterrhopterix fusca,* Körper gestreckt

Abb.12: ♀ von *Apterona helicoidella,* der Körper ist stark gebogen. (aus: "Schmetterlinge und ihre Lebensräume Bd.2", gez. W. ETTMÜLLER)

Schlüssel für Puppen (Bis Tribus soweit möglich)

Die Anhänge der Puppenhüllen (Exuvien) sind oft etwas asymmetrisch ausgebildet, wenn möglich mehrere Exemplare vergleichen ! Der Schlüssel ist mit Vorsicht zu gebrauchen, da bisher nur ein Teil der Gattungen untersucht werden konnte. Ganz fehlen die Dissoctenioidini, Placodomini und *Solemasia.*

Abkürzungen wie im Hauptschlüssel.



1) ♂ ♀ Dorne auf den Abdominaltergiten in Feldern angeordnet (Abb.1). Puppe tritt beim Schlüpfen aus den Sack vor, dieser ist dreikantig. Kopf mit 2 Borstenpaaren. 2
- ♂ ♀ Dorsale Dorne in Reihen angeordnet (Abb.2). Sack nicht dreikantig. Kopf mit 4-5 Borstenpaaren. 3

2) ♂ ♀ Scheiden der Labialpalpen bis zum Ende parallel (Abb.3). **Naryciinae** 13
- ♀ Scheiden der Labialpalpen am Ende divergierend (Abb.4). **Taleporiinae** 14

3) Fl-Scheiden voll entwickelt. Puppe schiebt sich beim Schlüpfen ein Stück weit aus dem Sack hervor. (Hieher alle ♂ sowie die ♀ der in beiden Geschlechtern geflügelten Gattungen). 8
- Fl-Scheiden reduziert (Hieher nur ♀). 4

4) Die Puppe tritt beim Schlüpfen aus dem Sack vor. Labialpalpenscheiden kurz, dreieckig, wenig länger als die Rüsselscheiden (Abb. 5). Vordere Reihe der Tergaldornen auf den Abdominalsegmenten nach hinten gerichtet, hintere Reihe nach vorn. (excl. *Dissoctena*). Kopf mit 4 oder 5 Borstenpaaren, davon 1-2

Abb.1: Dornenfelder auf den Abdominaltergiten der Puppen beider Geschlechter. (Aus: "Schmetterlinge und ihre Lebensräume, Bd. 2", gez. W. ETTMÜLLER)

Abb.2: Dornenreihen auf den Abdominaltergiten der Puppen beider Geschlechter. (Aus: "Schmetterlinge und ihre Lebensräume, Bd. 2", gez. W. ETTMÜLLER)

auf dem Scheitel. ♀ **Typhoniini p.p.** 15
- Puppe bleibt beim Schlüpfen im Sack. 5

5) Ant-Scheiden überragen den Rand des Kopfschildes deutlich (Abb.3, 11A-C). Fl-Scheiden noch vorhanden. ♀ **Psychinae** 16
- Ant-Scheiden nur etwa so lang wie der Kopf, manchmal kaum noch erkennbar (Abb.6). 6

6) Fl-Scheiden noch vorhanden. Ant-Scheiden manchmal noch deutlich erkennbar (Abb.11, D-H). ♀ **Epichnopteriginae** 17
- Fl-Scheiden fehlen (rudimentär bei *Oiketicoides*). Stets starke Verschmelzungen im Bereich des Kopfes, die Ant-Scheiden sind kaum noch erkennbar (Abb.12). 7

7) Puppensack an einem Faden aufgehängt. Kopf und Prothorax der Exuvie auffallend dünn und schwach sklerotisiet. ♀ **Metisinae**
- Puppensack auf der Unterlage festgesponnen oder frei am Boden liegend. Ganze Puppe gleich stark sklerotisiert. ♀ **Oiketicinae**

8) Ant-Scheiden an der Basis breit, dann allmählich zugespitzt (Ant dkz). Hieher nur ♂♂. 10
- Ant-Scheiden gleichmässig schlank (Ant einfach). 9

9) Labialpalpenscheiden relativ lang, um ein mehrfaches länger als die kleinen Rüsselscheiden. (Abb.8,10A). ♂ ♀ ***Eumasia***
- (Unterschiede gegen vorige zu prüfen, liegt uns nicht vor). ***Placodoma***
- ♀ Labialpalpenscheiden deutlich kürzer, nur wenig länger als die Rüsselscheiden. ***Penestoglossa***

10) Kopf mit Stirnhöcker (Abb.5), mit 5 Borstenpaaren, davon 2 auf dem Scheitel. ♂ ♀ **Typhoniini p.p.** 15
- Kopf ohne Stirnhöcker, mit 4 Borstenpaaren, davon 1 auf dem Scheitel. 11

11) Puppensack an einem Faden aufgehängt. ♂ **Metisinae**
- Puppensack auf der Unterlage festgesponnen oder frei am Boden liegend. 12

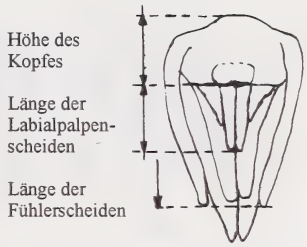


Abb.3: Kopf-Brust-Schild einer ♀ Puppe einer Naryciini

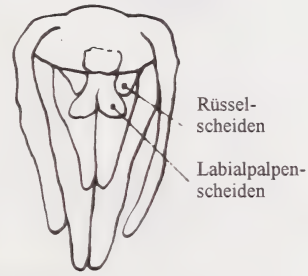


Abb.4: Kopf-Brust-Schild einer ♀ Puppe einer Taleporiini

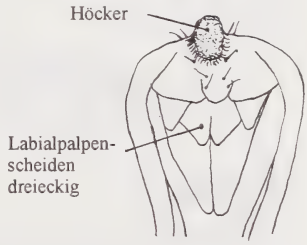


Abb.5: Kopf-Brust-Schild einer ♀ Puppe einer Typhoniini

Abb.6: Kopf-Brust-Schild einer ♀ Puppe einer Epichnopterigini

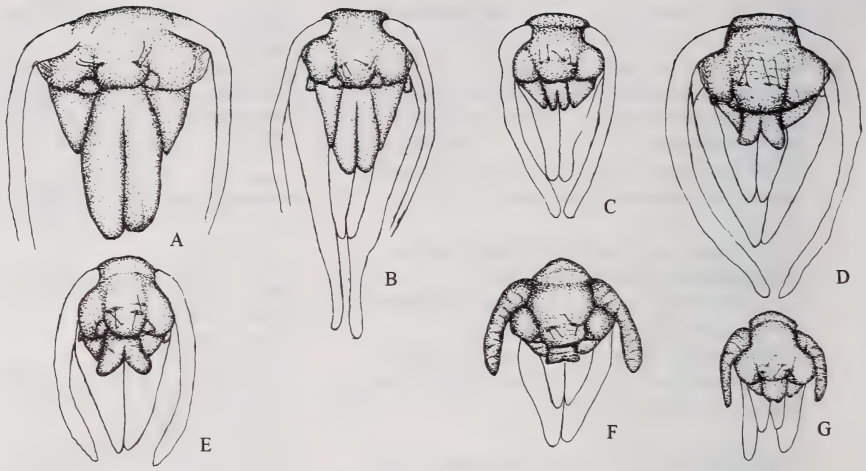


Abb.7: Kopfschilder von ♀ Puppen der Naryciinae und Taleporiinae. A = *Diplodoma laichartingella* (Beinscheiden nicht gezeichnet), B = *Narycia duplicella,* C = *Dahlica lichenella,* D = *Taleporia tubulosa,* E = *Pseudobankesia alpestrella,* F = *Bankesia conspurcatella,* G = *Brevantennia siederi.*

12) Sack schneckenhausartig gewunden.
♂ Apteronini

\- Sack nicht schneckenhausartig.
♂ Typhoniinae pp. **(Penestoglossini)**
♂ Psychinae,
♂ Epichnopteriginae,
♂ Oiketicinae (ohne Apteronini)
(sichere Trennung der Unterfamilien derzeit nicht möglich).

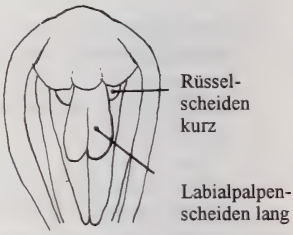


Abb.8: Kopf-Brust-Schild einer ♀ Puppe von *Eumasia parietariella*

Naryciinae

13) ♀ Labialpalpenscheiden viel länger als die Rüsselscheiden, etwa so lang wie der Kopf (Abb.3, 7A, B). Fl-Scheiden voll entwickelt.
Naryciini

\- ♀ Labialpalpenscheiden ebenso lang wie die Rüsselscheiden, kürzer als der Kopf (Abb.7C, G, 9). Fl-Scheiden verkürzt. **Dahlicini**

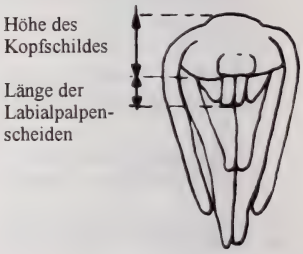


Abb.9: Kopf-Brust-Schild einer ♀ Puppe, Beispiel einer Dahlicini

Taleporiinae

14) ♀ Fl-Scheiden voll entwickelt. **Eotaleporiini**

\- ♀ Fl-Scheiden verkürzt, Kopfplatten Abb.7D, E, F). **Taleporiini**

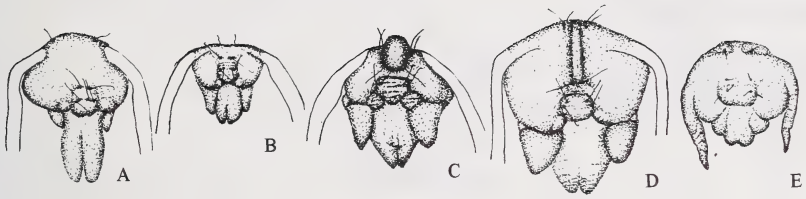


Abb.10: Kopfplatten von ♀ Puppen der Gattung *Eumasia*, der Typhoniinae und der Peloponnesini. A = *Eumasia parietariella*, B = *Penestoglossa dardoinella*, C = *Typhonia ciliaris*, D = *Dissoctena granigerella*, E = *Peloponnesia glaphyrella*.

Typhoniinae (Abb.10)

15) ♂ ♀ Kopf mit 5 Borstenpaaren, davon 2 auf dem Scheitel. Auffälliger Stirnvorsprung (Höcker) zwischen den Ant Basen (Abb.5). Fl-Scheiden ♀ rudimentär oder (*Dissoctena*) verkürzt, oder voll entwickelt (*Typhonia*). **Typhoniini**

- Kopf mit 4 Borstenpaaren, davon 1 auf dem Scheitel. Ohne Stirnhöcker. ♀ Fl-Scheiden vollständig (*Eumelasina* ?). **Penestoglossini**

Psychinae

16) ♀ Ant-Scheiden etwa gleich lang oder wenig länger als der Kopf (Abb.10E). **Peloponnesiini**

- ♀ Ant Scheiden viel länger als der Kopf (Abb.11 A-C). **Psychini**

Epichnopteriginae

17) ♀ Beinscheiden vorhanden jedoch stark rückgebildet, Gliederung selten noch sichtbar. Ant-Scheiden kurz, überragen den Kopf kaum. Wenn Ant-Scheiden mit Kopf verschmolzen, dann ist dieser wesentlich breiter als hoch (Abb.11D-G). **Epichnopterigini**

- ♀ Kopf etwa gleich breit wie hoch. An Stelle der Beinscheiden sind nur noch Ausstülpungen erkennbar. Ant-Scheiden mit Kopf verwachsen (Abb.11 H). **Stichobasini**

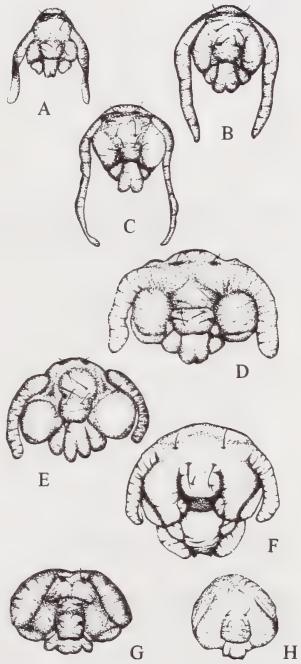


Abb.11: Kopfschilder von ♀ Puppen der Psychinae und Epichnopteriginae
A = *Luffia lapidella*
B = *Proutia betulina*
C = *Psyche casta*
D = *Bijugis bombycella* ssp. *helvetica*
E = *Reisseronia magna*
F = *Rebelia kruegeri*
G = *Epichnopterix plumella*
H = *Stichobasis helicinoides*

Oiketicinae ♂ ♀ (Abb.12)

18) Sack schneckenhausartig gewunden, etwa 2 1/2 Umgänge. **Apteronini**
- Sack gerade oder leicht gebogen. **Acanthopsychini** **Oreopsychini** **Phalacropterigini**

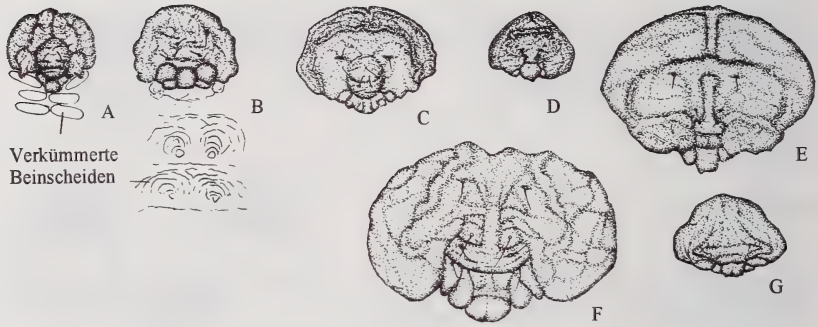


Abb.12: Kopfplatten von ♀ Puppen der Oiketicinae. A = *Amicta cabrerai,* B = *Canephora unicolor,* C = *Phalacropterix praecellens,* D = *Oreopsyche tenella,* E = *Ptilocephala plumifera,* F = *P. pyrenaella,* G = *Apterona helicoidella*

Merkmals - Matrix

Diese Tabelle (siehe die nachfolgenden fünf Seiten) enthält die systematisch wichtigen Merkmale für alle Gattungen. Deren Reihenfolge entspricht der Liste im I. Teil (SAUTER & HÄTTENSCHWILER 1991). Die wichtigsten nomenklatorischen Änderungen sind jedoch berücksichtigt.

*** Bemerkung zum Merkmal "Legeröhre der ♀♀":
L = Legeröhre lang ausstreckbar, stark sklerotisiert. K = Legeapparat klein, oft unauffällig, nicht ausstreckbar, schwach sklerotisiert. 1/2 = Legeapparat wulstig, wenig länger als ihr Durchmesser, nur schwach sklerotisiert, nicht ausstreckbar. 1/4 = Legeapparat wulstig, kaum so lang wie dessen Durchmesser, nur schwach sklerotisiert, nicht ausstreckbar.

+ = vorhanden
- = fehlt ganz oder weitgehend
r = rudimentär noch vorhanden, gut sichtbar
v = variabel
= nicht bekannt

	Flügel	Flügelscheiden der Puppe	Beine	Beinscheiden der Puppe	Fühler	Fühlerscheiden an der Puppe	Afterwolle, K=Kranz, V=ventral, M=mehrere Kränze	Legeröhre, L=lang, K=kurz ***, 1/2 bzw.1/4=verkürzt	Palpen k=kurz Zahl=Anzahl der Glieder	Ocellen	Ocellen	Palpen k=kurz Zahl=Anzahl der Glieder	V-Tibia, Epiphyse K=klein, G=gross	M-Tibia Anzahl Sporne	H-Tibia Anzahl Sporne	Vorderflügel, Anzahl Adern aus der Discoidalzelle	Vorderflügel: Eingeschobene Zelle	Vorderflügel: Anhangzelle	Hinterflügel: Anzahl Adern aus der Discoidalzelle	Hinterflügel: Eingeschobene Zelle	Fühler, f=fadenförmig d=doppelkammzähnig	Kammzähne: b=beschuppt u=unbeschuppt	Flügelbeschuppung: e=einspitzig, m=mehrspitzig	Genital: Saccus. l=lang, k=kurz, - =fehlt ganz	Gabel am 8 Abdominalsternit	Borstenpaare auf Puppen-Kopfplatte	Dorsaldornen auf Puppe: F=Feld,V=vor,R= rückwärts.	Wo findet Copula statt ?	Anmerkungen
				♀	♀													♂	♂							♀	♀	+ ♂	♂
NARYCIINAE																													
Naryciini																													
Diplodoma	+	+	+	+	+	+	K	L	+3	+	+	+3	G*	2	4	10	+	+	6	+	f	-	m	k	-	2	F	entfernt	*1
Narycia	+	+	+	+	+	+	K	L	+3	-	-	+3	G*	2	4	9	-	+	6	-	f	-	m	-	-	2	F	entfernt	*1
Paranarychia	+	+	+	+	+	+		L	+3	-	-	+3	-/k	2	2	9	-	-	6	+	f	-	m	-	-			entfernt	*1
Dahlicini																													
Eosolenobia	-	+	+	+	+	+	v	L	+1	-	-	+2	-	2	4	9	+	+	6	+	f	-	m	-	-	2	F	am Sack	*2
Praesolenobia	-	+	+	+	+	+	v	L	+1	-	-	+2	-	2	4	9	-	+	6	-	f	-	m	-	-	2	F	am Sack	*2
Dahlica	-	+	+	+	+	+	v	L	+1	-	-	+2	-	2	4	9	-	+	6	-	f	-	e/m	-	-	2	F	am Sack	*2
Siederia	-	+	+	+	+	+	v	L	+1	-	.	+1	k	2	4	9	-	+	6	-	f	-	m	-	-	2	F	am Sack	*2
Postsolenobia	-	+	+	+	+	+	v	L	+1	-	-	+2	-	2	4	9	-	-	5	-	f	-	m	-	-	2	F	am Sack	*2
Brevantennia	-	+	+	+	+	+	v	L		-	-	+1	-	2	4	9	-	-	6	-	f	-	m	-	-	2	F	am Sack	*2
TALEPORIINAE																													
Eotaleporiini																													
Eotaleporia	+	+	+	+	+	+	K	L	+3	+	+	+3	-?	-2	4	9	-	-	6	+	f	-	b	-	-	3	-R	entfernt	*3
Taleporiini																													
Altobankesia	-		+	+	+	+			+3	-	-	+3	k	2	4	9	-	+	6	-	f	-		-	-			entfernt	*4
Taleporia	-	+	+	+	+	+	K	L	-	-	+	+3	k	2	4	10	-	+	6	-	f	-	m	k	-	2	F	am Sack	*4
Pseudobankesia	-	+	+	+	+	+	K	L	r	-	+	+3	k	2	4	10	-	+	6	-	f	-	m	k	-	2	F	am Sack	*4*5
Bankesia	-	+	+	+	+	+	K	L	-	-	+	+3	k	2	4	9	-	+	6	-	f	-	m	-	-	2	F	am Sack	*4*6
Sciopetris	-		+	+	+	+		L		-	+	+3	k	2	4	8	-	-	5	-	f	-	m	-	-			am Sack	*4
Kozhantshikovia	-		+	+	+	+	K	L	r	-	-	+2	k	2	4	9	-	-	6	-	f	-		L	-			am Sack	*4

G* = Naryciini hat am Vorderbein keine Epiphyse sondern einen Borstenpinsel, der wohl dem gleichen Zwecke dient. Flüchtig betrachtet erscheint dieser Pinsel wie eine Epiphyse.

*1 = Aedeagus gebogen, Labialpalpen 3-gliedrig, mit Stützstab
*2 = Aedeagus gebogen, Labialpalpen auf ein Glied reduziert, mit Stützstab
*3 = Aedeagus gestreckt, Labialpalpen gut entwickelt, ohne Stützstab
*4 = Aedeagus gestreckt, ohne Stützstab
*5 = Weibchen mit 5 Tarsengliedern
*6 = Weibchen mit 3 Tarsengliedern

+ = vorhanden
- = fehlt ganz oder weitgehend
r = rudimentär noch vorhanden, gut sichtbar
v = variabel
= nicht bekannt

	Flügel	Flügelscheiden der Puppe	Beine	Beinscheiden der Puppe ♀	Fühler ♀	Fühlerscheiden an der Puppe	Afterwolle, K=Kranz, V=ventral, M=mehrere Kränze	Legeröhre, L=lang, K=kurz, 1/2 bzw. 1/4=verkürzt ***	Palpen k=kurz Zahl=Anzahl der Glieder	Ocellen
PLACODOMINAE										
Placodomini										
Placodoma	+	+	+	+	+	+	K	L		-
Incertae sedis										
Eumasia	+	+	+	+	+	+	K	L	+3	-
Solemasia			+	+	+	+				-
TYPHONIINAE										
Penestoglossini										
Eumelasina	r	+	+	+	+	+		L		
Penestoglossa	+	+	+	+	+	+	K	L	+k	-
Dissoctenioidini										
Dissoctenioides	+	+	+	+	+	+		L	+3	
Typhoniini										
Typhonia	+	+	+	+	+	+	K	L	+k	-
Dissoctena	-	+	+	+	+	+	K	L	-	-
Eudissoctena	-		+	+	+	+			r	-
Eochorica	-		+	+	+	+	K	L	+k	-
Melapsyche										

	Ocellen	Palpen k=kurz Zahl=Anzahl der Glieder	V-Tibia, Epiphyse K=klein, G=gross	M-Tibia Anzahl Sporne	H-Tibia Anzahl Sporne	Vorderflügel, Anzahl Adern aus der Discoidalzelle	Vorderflügel: Eingeschobene Zelle	Vorderflügel: Anhangzelle ♂	Hinterflügel: Anzahl Adern aus der Discoidalzelle ♂	Hinterflügel: Eingeschobene Zelle	Fühler, f=fadenförmig d=doppelkammzähnig	Kammzähne, b=beschuppt u=unbeschuppt	Flügelbeschuppung: e=einspitzig, m=mehrspitzig	Genital, Saccus. l=lang, k=kurz, - =fehlt ganz	Gabel am 8 Abdominalsternit
PLACODOMINAE															
Placodomini															
Placodoma	-	+3	G	2	4	8-9	+	+	6	-	f	-b	-	-	
Incertae sedis															
Eumasia	-	+3	G*	2	4	7	-	-	5	-	f	-	m	K	-
Solemasia	-		G	2		7	-	-	5	-	f	-			
TYPHONIINAE															
Penestoglossini															
Eumelasina			G	2	2/4	10	-	++	6	-	d				
Penestoglossa	-	+3	G	2	4	9	+	+	5	-	d	u	m	K	-
Dissoctenioidini															
Dissoctenioides			-	2	4	9	-	+	5	-	d			L?	-
Typhoniini															
Typhonia	-	+k	G	2	4	10	+	+	6	-	d	b	m	K	-
Dissoctena	-	r	-	2	4	10	+	+	5	-	d	b	m	K	-
Eudissoctena	-	+k	G	2	4	10	+	+	6	-	d	b	m		
Eochorica	-	+3	G	2	4	10	-	+	6	-	d	b	m	K	-
Melapsyche				2	4	10	+	-	6	-	d				

	Borstenpaare auf Puppen-Kopfplatte	Dorsaldornen auf Puppe: F=Feld, V=vor, R= rückwärts. ♀	Wo findet Copula statt ? ♀ + ♂	Anmerkungen ♂
PLACODOMINAE				
Placodomini				
Placodoma			entfernt	*1
Incertae sedis				
Eumasia	*4	VR	entfernt	*2
Solemasia				
TYPHONIINAE				
Penestoglossini				
Eumelasina				*6
Penestoglossa	*4	VR	entfernt	*1*7
Dissoctenioidini				
Dissoctenioides			entfernt	*2
Typhoniini				
Typhonia	5**	VR	entfernt	*3*4
Dissoctena	5**	R	entfernt	*3
Eudissoctena			entfernt	*3
Eochorica			entfernt	*3*5
Melapsyche				*3

G*= *Eumasia* trägt einen Borstenpinsel, bei einigen Arten kombiniert mit kleiner Epiphyse
* = Ein Borstenpaar auf dem Scheitel
** = Zwei Borstenpaare auf dem Scheitel
*1 = Labialpalpen 3 Glieder, nach vorn gestreckt
*2 = Labialpalpen 3 Glieder hängend
*3 = Puppenkopfplatte mit "Höcker"
*4 = Labialpalpen kurz, 1 (-3) Glieder
*5 = Labialpalpen kurz, 3 Glieder
*6 = Aedeagus stark gebogen, hufeisenförmig
*7 = Aedeagus gerade (gestreckt)

+ = vorhanden
- = fehlt ganz oder weitgehend
r = rudimentär noch vorhanden, gut sichtbar
v = variabel
= nicht bekannt

	Flügel	Flügelscheiden der Puppe	Beine	Beinscheiden der Puppe	Fühler	Fühlerscheiden an der Puppe	Afterwolle, K=Kranz, V=ventral, M=mehrere Kränze	Legeröhre, L=lang, K=kurz *** 1/2 bzw.1/4=verkürzt	Palpen k=kurz Zahl=Anzahl der Glieder	Ocellen	Ocellen	Palpen k=kurz Zahl=Anzahl der Glieder	V-Tibia, Epiphyse K=klein, G=gross	M-Tibia Anzahl Sporne	H-Tibia Anzahl Sporne	Vorderflügel, Anzahl Adern aus der Discoidalzelle	Vorderflügel: Eingeschobene Zelle	Vorderflügel: Anhangzelle	Hinterflügel: Anzahl Adern aus der Discoidalzelle	Hinterflügel: Eingeschobene Zelle	Fühler, f=fadenförmig d=doppelkammzähnig	Kammzähne: b=beschuppt u=unbeschuppt	Flügelbeschuppung: e=einspitzig, m=mehrspitzig	Genital, Saccus. l=lang, k=kurz, - =fehlt ganz	Gabel am 8 Abdominalsternit	Borstenpaare auf Puppen-Kopfplatte	Dorsaldornen auf Puppe: F=Feld,V=vor,R= rückwärts.	Wo findet Copula statt ?	Anmerkungen
				♀	♀														♂	♂						♀	♀	+ ♂	♂
PSYCHINAE																													
Psychini																													
Luffia	-	+	+	+	+	+	K	L	-	-	-	r	G	2	4	9	-	+	5-6	-	d	u	m	K	-	4	VR	am Sack	*1
Bacotia	-	+	+	+	+	+	K	L	-	-	-	r	G	2	4	9	-	+	5-6	-	d	u	m	K	-	4	VR	am Sack	*2
Proutia	-	+	+	+	+	+	K	L	-	-	-	r	G	2	4	9	+	-	5	-	d	u/b	m	K	-	4	VR	am Sack	*2
Bruandia	-	+	+	+	+	+	K	L	-	-	-	r	G	2	4	9	+	-	5	-	d	u/b	m	K	-	4	VR	am Sack	*1
Psyche	-	+	+	+	+	+	K	L	-	-	-	r	G	2	4	9	-	-	5	-	d	b	m	K	-	4	VR	am Sack	*2
Atelopsyche											+																		*3
Peloponnesiini																													
Peloponnesia	-	+	+	+	+	+	K	L	r	-	-	r	-	2	4	9	+	-	5	-	d	b	m	K	-	4	VR	am Sack	
Pseudofumea	-		+	+	+	+	K	L	-	-			-	2	4	9	-	-	5	-	d			L?				am Sack	
EPICHNOPTERIGINAE																													
Epichnopterigini																													
Bijugis	-	+	+	+	+	+	K	1/2	-	-	-	r	G	2	4	9	+	-	5	-	d	u	m	-K	-	4	VR	im Sack	*4
Reisseronia	-	+	+	+	+	+	K	1/2	-	-	-	r	-	2	4	8	+	-	5	-	d	u	e/m	-	-	4	VR	im Sack	*4
Heliopsychidea	-	+	+	+	+	+	K	1/4	-	-	-	r	G	2	4	9	+	-	5	-	d	u	e/m	K	-	4	VR	im Sack	*4
Montanima	-		+	+	+	+	K	1/4	-	-	-	r	G	2	4	9	+	-	5	-	d	u	e	K	-	4	VR	im Sack	*4*8
Rebelia	-	r	r	+	r	+	M	1/4	-	-	-	r	G	2	4	9	+	-	5	-	d	u	e	K	-	4	VR	im Sack	*5*8
Psychidopsis										-	-	r	G	2	4	8	-	-	5	-	d							im Sack	*5
Psychocentra											-	r	G	2	4	6?	+	-	5	-	d								*5*6
Psychidea	-	+	r	+	r	+	M	1/4	-	-	-	r	-	2	4	9	+	-	5	-	d	u	e	K	-	4	VR	im Sack	*5
Acentra	-		r		r					-	-	r	-	2	4	9	+	-	5	-	d	u	e					im Sack	*5
Epichnopterix	-	r	r	r	-	-	M	1/4	-	-	-	r	-	2	4	8	+/-	-	5	-	d	u	e	K	-	4	VR	im Sack	*5
Whittleia	-		r		r		M			_	-	r	-	2	4	8	+	-	5	-	d	u	e			4	VR	im Sack	*5
Stichobasini																													
Stichobasis	-	r	r	r	r	-	K?	1/4	-	-	-	r	-	2	2	8	-	-	5	-	d	u	e	-K	-	4	-?	im Sack	*7

*1 = Vorderflügel mit Gitterung
*2 = Vorderflügel ohne Gitterung
*3 = Nur ein Exemplar bekannt, Tineidae ?
*4 = Weibchen: Beine lang jedoch funktionsuntüchtig, Legeröhre halblang, nicht ausziehbar
*5 = Weibchen: Beine nur Stummel, Legeröhre kürzer als obere Gruppe
*6 = Nur ein Exemplar bekannt
*7 = Männchen sehr lange Palpen, Weibchen Beine nur kurze Stummel
*8 = Bedornung von Intersegmentalhaut 7/8

+ = vorhanden
- = fehlt ganz oder weitgehend
r = rudimentär noch vorhanden, gut sichtbar
v = variabel
= nicht bekannt

–	Flügel	Flügelscheiden der Puppe	Beine	Beinscheiden der Puppe	Fühler	Fühlerscheiden an der Puppe	Afterwolle, K=Kranz, V=ventral, M=mehrere Kränze	Legeröhre. L=lang, K=kurz *** 1/2 bzw 1/4=verkürzt	Palpen k=kurz Zahl=Anzahl der Glieder	Ocellen
METISINAE										
Metisini										
Metisa	-	-	r	r	-	-	M	K	-	-
Eumetisa	-		-		-					-
Brachycyttarus	-		-		-		M	K	-	-
Pteroma	-	-	-	-	-	-	M	K	-	-
OIKETICINAE										
Acanthopsychini										
Amicta	-	-	-	r	-	-	M	K	-	-
Oiketicoides	-	r	r	r	-	-	M	K	-	-
Eumeta	-	-	rv	r	-	-	M	K	-	-
Manatha	-	-	-	-	-	-	M	K	-	-
Urobarba	-		-		-					
Nipponopsyche	-	-	-	-	-	-		K	-	-
Mahasena	-	-	r	r	-	-	M	K	-	-
Ptilamicta										
Acanthopsyche	-	-	-	r	-	-	M	K	-	-
Canephora	-	-	r	r	-	-	M	K	-	-
Bambalina	-	-	-	-	-	-	M	K	-	-
Pachythelia	-	-	r	r	-	-	M	K	-	-
Auchmophila	-		r		-					-
Kotochalia	-	-	-	-	-	-	M	K	-	-
Chaliopsis	-	-	-	-	-	-	M	K	-	-
Chalioides	-	-	-	r	-	-	M	K	-	-
Aspina	-								-	-

–	Ocellen	Palpen k=kurz Zahl=Anzahl der Glieder	V-Tibia, Epiphyse K=klein, G=gross	M-Tibia Anzahl Sporne	H-Tibia Anzahl Sporne	Vorderflügel, Anzahl Adern aus der Discoidalzelle	Vorderflügel: Eingeschobene Zelle	Vorderflügel: Anhangzelle	Hinterflügel: Anzahl Adern aus der Discoidalzelle	Hinterflügel: Eingeschobene Zelle	Fühler. f=fadenförmig d=doppelkammzähnig	Kammzähne. b=beschuppt u=unbeschuppt	Flügelbeschuppung: * e=einspitzig, m=mehrspitzig	Genital, Saccus. l=lang, k=kurz, - =fehlt ganz	Gabel am 8 Abdominalsternit
METISINAE															
Metisini															
Metisa	-	-	G	-	-	10	+	-	6	+	d	b	e	-	-
Eumetisa	-	-	G			10	-	-	6	-	d				
Brachycyttarus	-	-	G	-	-	9	-/+	-	5-6	-	d	b	m	-	-
Pteroma	-	-	G	-	-	8-10	-	-	5-6	-	d	u	m	-k	-
OIKETICINAE															
Acanthopsychini															
Amicta	-	-	G	-	-	10	-	-	6	-	d	b	e/m	K	+
Oiketicoides	-	-	G	-	-	10	-	-	6	-	d	u	e/m	K	+
Eumeta	-	-	G	-	-	10	+	-	6	+	d	u	m	K	
Manatha	-	-	G	-	-	8-10	-	-	4-6	-	d	b	m	L	r
Urobarba	-	-	G	-	-	10	-	-	4	-	d	u	e		
Nipponopsyche	-	-	G	-	-	9	-	-	5	-	d			K	+
Mahasena	-	-	G	-	-	10	+	-	6	+	d	u/b	m	L	+
Ptilamicta			G	-	-	9	-	-	4	-	d			K	
Acanthopsyche	-	-	G-	-	-	9	-	-	5	-	d	u/b	e	K	+
Canephora	-	-	G	-	-	9	-	-	5	-	d	b	m	K	+
Bambalina	-	-	G	-	-	10	+	-	5	-	d	u	m	K	+
Pachythelia	-	-	G	-	-	9	-	-	5	-	d	u/b	e	K	+
Auchmophila	-	-	G	-	-	9	+	-	4	+	d				
Kotochalia	-	-	G	-	-	9	+	-	6	+	d	u	-	L	+
Chaliopsis	-	-	G	-	-	9	+	-	5-6	+	d	u			+
Chalioides	-	-	-	-	-	9	+	-	6	-	d	u	-/m	K	+
Aspina	-	-	-	-	-	9	-	-	5	-	d				

–	Borstenpaare auf Puppen-Kopfplatte	Dorsaldornen auf Puppe: F=Feld, V=vor, R= rückwärts.	Wo findet Copula statt ?	Anmerkungen
METISINAE				
Metisini				
Metisa	4	VR	im Sack	*1
Eumetisa			im Sack	*1
Brachycyttarus	4	VR	im Sack	*1
Pteroma	4	VR	im Sack	*1
OIKETICINAE				
Acanthopsychini				
Amicta	4	VR	in Puppe	*2
Oiketicoides	4	VR	im Sack	*3
Eumeta	4	VR	im Sack	
Manatha	4	VR	im Sack	
Urobarba			im Sack	
Nipponopsyche			im Sack	
Mahasena	4	VR	im Sack	
Ptilamicta				
Acanthopsyche	4	VR	im Sack	*4
Canephora	4	VR	im Sack	
Bambalina	4	VR	im Sack	
Pachythelia	4	VR	im Sack	
Auchmophila			im Sack	
Kotochalia	4	VR	im Sack	*5
Chaliopsis	4	VR	im Sack	*5
Chalioides	4	VR	im Sack	*6
Aspina				*3

*1 = Sack an Faden aufgehängt, Hinterflügel sc / rr entspringen getrennt und und vereinigen sich nachher
*2 = Paarung teilweise in Puppe, Hinterflügel sc / rr kurz anastomosierend
*3 = Hinterflügel sc ganz frei
*4 = Antennen teilweise sehr schwach beschuppt
*5 = Hinterflügel sc / rr verschmolzen
*6 = Aderung variabel, EZ in Vfl und Hfl oft undeutlich, sc + rr von Basis bis etwa Zellmitte verschmolzen

+ = vorhanden
- = fehlt ganz oder weitgehend
r = rudimentär noch vorhanden, gut sichtbar
v = variabel
= nicht bekannt

| | ♀♀ | | |

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Zdravko Lorković (1900–1998): short biography and scientific work

Zdravko Lorković was an eminent biologist in world terms and one of the greatest in Croatia in the 20th Century. He was an entomologist and lepidopterist, taxonomist and ecologist, a geneticist and experimental biologist; and, an expert in all these fields. He was born in Zagreb, Croatia and spent the whole of his life there. He studied Natural Sciences at the Faculty of Philosophy, University of Zagreb, then became assistant in the

Mineralogical and Petrological Museum, under Professor F. Tućan, and later assistant at the Biological Institute of the Faculty of Medicine under Professor B. Zarnik. He received his Ph.D in 1928 and was for many years Professor of Biology at the Medical and Veterinary faculties. At the same time he taught zoology and entomology to students of the Agriculture and Forestry Faculty, and genetics to students of the Natural Science Faculty and to post-graduate students of the University of Zagreb. From 1965 he was a regular member of the Yugoslav Academy of Sciences and Arts (now, the Croatian Academy of Sciences and Arts). He was a member of the Zoological Academy in Agra (India), the European Lepidopterological Society, the Lepidopterists' Society of the USA, the Entomological Society of the Kingdom of Serbs, Croats and Slovenians, the Yugoslav Entomological Society, the Croatian Entomological Society and the Croatian Biological Society. He was, for many years, the chief editor of the journal *Acta entomologica jugoslavica* and during the last years of *Entomologia Croatica*. He was also on the editorial boards of the journals *Genetika, Periodicum biologorum, Natura Croatica* and *Shilap*. He published 86 scientific papers (including three important summaries of congress reports), and more than 50 professional papers, congress reports and obituaries.

For many Holarctic lepidopterists Lorković was, above all, a highly respected taxonomist (Lorković, 1927, 1930–31, 1938, 1943, 1950, 1953c, 1955c, 1960, 1967, 1968, 1969, 1976a, 1985, 1989b, 1993a, 1998). As a butterfly specialist, especially in Pieridae, Lycaenidae and Nymphalidae (incl. Satyrinae), he described several new butterfly species, namely *Leptidea lactea* Lorković, 1950, *Erebia calcaria* Lorković, 1953, *E. nivalis* Lorković & de Lesse, 1954, *Pieris (napi) balcana* Lorković, [1970]. He also described many subspecies, for example, *Cupido argiades tibetanus* Lorković, 1943, *Erebia styx trentae* Lorković, 1952, *E. gorge vagana* Lorković, 1955, *E. stirius kleki* Lorković, 1955, *Leptidea reali melanogyna* Lorković, 1993. In making taxonomic revisions, before the advent of modern sophisticated computer methods, he established the foundations of distinguishing among closely related and phenotypically similar species. He did so by identifying discontinuities arising from the correlation of inherited qualitative and quantitative characteristics (Lorković's method

with estimation of total and partial transitions; Lorković, 1927, 1928, 1943) generated by reproductive isolation. At the same time, he recognised the taxonomic importance of morphological differences in non-functional parts of organs (Lorković, 1931, 1953a, 1955a).

Professor Lorković was one of the pioneers in the experimental investigations of phenotypic plasticity of butterfly pupae (Lorković, 1929a) and of seasonal polyphenism among butterflies in the temperate zone (Lorković, 1929b). From the time of his dissertation onwards, he devoted practically the whole of his life to the study of speciation. From the very onset of his scientific work, it was clear that he supported the idea of evolution accepted in its entirety today. He was cited by evolutionist Ernst Mayr himself (1963) as author of a classic example of a complex morphological, genetic and ecological analysis of sibling species of butterflies of the genus *Everes* (= *Cupido*). In this work, dating from the first half of the 20th Century (Lorković, 1928, 1938, 1942, 1943), he gave firm support to the biological species concept. Professor Lorković was one of the pioneers of cytotaxonomy, and was the first to report the number of haploid chromosomes for more than 60 species of Palaearctic butterflies (Lorković, 1941, 1952, 1966, 1968). He was the founder of the hypothesis that through diffuse kinetochore-induced ploidy the appearance of exceptionally large (*Leptidea, Polyommatus*) or small (*Erebia*) numbers of chromosomes in butterflies could be explained (Lorković, 1941, 1949). His great knowledge of butterfly chromosomes and their meiotic behaviour (Lorković, 1974a, 1978) resulted in his being entrusted with the writing of a special chapter about chromosomes and their role in systematics and phylogeny in the book *Introduction to Lepidopterology* (Lorković, 1990) from the series of monographs *The Butterflies of Europe*.

Professor Lorković introduced new methods of artificial butterfly copulation (Lorković, 1947, 1953a), thereby increasing the experimental knowledge of phylogenetic relationships and the pathways of microevolution in butterflies (Lorković, 1978, 1997). In so doing, he demonstrated that, in nature, speciation occurs in different guises. Two of Lorković's examples are of special interest. The *Erebia tyndarus* group and the *Pieris napi* aggregate

illustrate taxa that have only partially undergone the process of differentiation through reproductive isolation into new species (Lorković, 1953b, 1953c, 1957, 1958b, 1962b. 1989a). For such taxa, he accepted and modified Mayr's definition of the concept of *semispecies*, and urged that the *semispecies* category be accepted in international rules of zoological nomenclature (Lorković, 1955b, 1958a, 1962a; Kiriakoff & Lorković, 1958; Lorković & Kiriakoff, 1958). This was eventually accomplished in nomenclature rule Article 6(b) for members of the *aggregate* (= Mayr's term 'superspecies') of *species* or *subspecies within a species* (ICZN, 3rd ed., 1985). He also recognised the independent existence of different reproductive isolation mechanisms (Lorković, 1958b, 1961b, 1978), and proved their independence of total genetic diversity (Lorković, 1986).

Professor Lorković bequeathed a collection of about 40,000 butterflies to the Croatian Natural History Museum in Zagreb. Half of these comprise a faunistic collection, mostly from the neighbourhood of Zagreb and from Mt. Velebit in Croatia, as well as from the Alps and the high mountains of the western Balkans. Half are specimens from crossing experiments (mainly between Pieridae from Europe, and with taxa from Asia and North America). Preserved with them is their documentation. The collection is kept as a special unit, with his microscope slides, library, letters, photographic documentation, diaries and notes in the Croatian Natural History Museum in Zagreb, where offprints of his papers can be obtained. (e-mail : Martina. Sasic@hpm.hr).

Chronological list of publications (co-)authored by Zdravko Lorković

1. Lorković, Z., 1923. Contribution to mineral deposits of Yugoslavia. — *Glasn. Hrvatsk. Prir. Društva* 35(1–2): 17–20 (in Croatian).
2. Lorković, Z., 1927. *Leptidea sinapis* ab. *major* Grund als selbständige Art aus Kroatien. — *Glasn.ent.društva kr.Srba, Hrvata i Slovenaca.* 2(1): 26–41, 2 Taf. (in Croatian, with German summary).
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Book reviews • Buchbesprechungen • Analyses

Báez, Marcos: Mariposas de Canarias.
15 × 21 cm, VI + 216 pp., 63 + 323 colour figures, paperback. Published by Editorial Rueda, S. L., Alcorcón (Madrid), 1998. ISBN 84-7207-110-3. To be ordered from Editorial Rueda, S. L., Porto Cristo 13, E-28924 Alcorcón (Madrid). Tel. 0091 619.27.79 – 619.25.64. Fax 0091 610.28.55.

Thirteen years after the publication of a field guide on the dragonflies of the Canary Islands, the present work deals with one of the best known and most popular insect groups of the Archipelago, the Lepidoptera. While these islands have, naturally, an impoverished fauna as far as the species number is concerned, the percentage of endemics is comparatively one of the highest of any region of the Western Palaearctic. At a time when considerable threats are imposed on nature in the Canaries, it is of great importance to document its biodiversity in order to demonstrate its high value and, ultimately, to ensure its long-term conservation. As far as the Lepidoptera are concerned, no less than about 200 out of the 600 species known from the Canaries are endemic to the Archipelago!

After a brief introductory section (pp. 1–13), dealing with topics like the origin of the Lepidoptera, their place in the ecosystems, variability and polymorphism, development and metamorphosis, larval morphology and diversity, the descriptive part starts with a brief overview of all known Lepidoptera families of the islands, for most of which a living specimen of one or two characteristic species is figured. The next section (pp. 36-201) makes up most of the remainder of the book. 303 species (nearly 50 %) of Canarian Lepidoptera are treated individually and set specimens are figured. All, or the very most of, the species of butterflies, sphingids, noctuids, geometrids and arctiids are shown, while a selection only (the most common or conspicuous, as well as the endemic species) of the "micro's" are dealt with. For each species, a brief description is presented, followed by a review of its distribution and status in the Canary Islands, and of its bionomics (habitat, phenology, larval host plants). A selective bibliography (only 31 entries), a systematic list of (all) Lepidoptera species known by then from the Archipelago, and an index of resp. its Lepidoptera and plant taxa close this pretty little book.

Taking into account what it is — a field guide and not an exhaustive monograph — this book is highly recommended to the lepidopterist travelling to the Canary Islands.

Alain Olivier

Kudrna, Otakar: Die Tagfalterfauna der Rhön.
14.5 × 20.5 cm, 166 pp., *Oedippus* 15: 1–158. 48 colour photographs, 2 + 110 maps, paperback. Published by Gesellschaft für Schmetterlingsschutz e.V., Dr. Otakar Kudrna, Brombergstraße 6, D-97424 Schweinfurt, Germany. Tel/fax: 0049 0 9721 805200; e-mail: kudrna.meb@t-online.de, 1998. ISSN 1436-5804. To be ordered from the publisher. Price: DEM 35.

Until about 15 years ago, the butterfly fauna of the valley of the Rhön — a hilly area situated in Central Germany, in the northwestern part of Bavaria and the adjacent border regions of Thuringia and Hesse — was insufficiently known, despite the fact that, with 109 indigenous species being known there at present, it is one of the lepidopterologically richest parts of Germany. There are various reasons to this: no heavy industry or high population density, high climatic and ecological diversity, resulting in a great variety of habitat types with many characteristic stenoecious butterfly species, a generally not too intensive land use. Some species are represented here by very strong populations for Central European standards. Six butterfly species — *Parnassius mnemosyne, Maculinea arion, M. nausithous, M. teleius, Euphydryas aurinia* and *Coenonympha hero* — that are listed in the annexes of the EU Habitat Directive (FFH) 94/43/EEC, are currently still extant in the Rhön, while two other ones (*Euphydryas maturna, Lasiommata achine*) have already become extinct in the Rhön, as have indeed 13 out of the 121 species that have been found in the district since about 1900. Ironically, mistaken management of nature reserves, implemented by the nature conservation authorities responsible, has been one of the causes of extinction, as the author illustrates by a series of examples. The successful re-establishment of the extinct *Colias palaeno* is documented.

Every single species is treated in the special part, with data on distribution, bionomics and conservation status. Intensive studies, carried out from 1984 until 1997, have resulted in the distribution atlas, which forms the second subdivision of the special part of the present study.

A conservation plan, aimed at the securing of strong (often not immediately threatened) populations of the most valuable species, is proposed. Species specific conservation measures (i.e. habitat management as it is practised for instance in Great Britain) are proposed for 18 priority species and their most important habitats. The great importance of monitoring of butterfly species and conservation measures is stressed. Conservation measures are also proposed for butterfly communities in the 26 most important sites. The localities have been selected after the principle of "critical faunas" and should enable the conservation of almost the whole species spectrum of the Rhön. Guidelines for habitat management for butterflies are outlined. Generously supported monitoring, surveillance and research without bureaucratic hindrance (e.g. the general ban on butterfly collecting in Germany!) of the field work and laboratory research are preconditions of success.

The study ends with a references list (77 entries) and an index. It will be of great interest for nature lovers concerned with butterflies. Many of the proposed measures for the protection of species and habitats can, with slight modifications perhaps, be applied to other taxa and areas. Therefore, it is also highly recommended literature to nature conservation authorities, that will hopefully pay more attention to invertebrates in general, and to butterfies, that are excellent bioindicators, especially. It is further of interest to both amateur and professional entomologists, both for its content and for the methodology behind it.

Alain Olivier

Tshikolovets, Vadim V.: The Butterflies of Turkmenistan.
21 × 30 cm, 237 pp., 24 colour plates with 1047 figures, 10 black-and-white plates with 66 figures, 4 + 157 maps, bound in coloured dust jacket. Published by the Author, Kiev, Brno, 30.XI.1998. ISBN 966-02-0511-2. To be ordered from: Willy De Prins, Diksmuidelaan 176, B-2600 Antwerpen, Belgium. Tel. 00323 322.02.35; e-mail: willy.deprins@village.uunet.be (Western Europe) or from Vadim V. Tshikolovets, Zoological Museum, B. Khmelnitsky str. 15, Kiev-MSP, UA-01601, Ukraine; e-mail: vadimchik@glul.apc.org (Eastern Europe). Price: BEF. 2,600 excl. postage.

One year and a half after the publication of his "Butterflies of Pamir", the author has produced the present work, dealing with the butterflies of Turkmenistan. In the Introduction, the history, geography, geomorphology, climate, vegetation and animal life of the present-day republic are reviewed, followed by a history of the study of butterflies in Turkmenistan and the obligatory Acknowledgements section. Then a list of localities is presented, with the names in use before 1991. The name is followed by a note, establishing whether it refers to a town, village, gorge, river, mountain (range) or nature reserve, and a code consisting of one letter (A to J) followed by one number (1 to 12), corresponding to squares on a map. This makes it easy to locate any locality mentioned in this work. An Abbreviations section applies to the museum collections referred to. Then follows a checklist of the species-group taxa said to occur within the boundaries of present-day Turkmenistan, with the exception of Kugitang in the extreme east, that belongs to the Pamiro-Alai. This region, covering a very small area, will be treated in a future book on the butterflies of Uzbekistan. The checklist includes 176 species-group taxa (actually 174 species, of which two — *Satyrus amasinus* and *Melitaea didyma* — include two subspecies each). The main body of the work, "A survey of Turkmenistan butterflies" (pp. 35–154) covers each taxon in detail. The species name (genus, species, author and date of publication) is followed by its range. Then comes the subspecies name (followed, when figured, by the reference to the illustrations on the corresponding plates at the end of the book) and the reference to the primary sources, i.e. the original literature reference (original combination and publication) and a list of the extant type material

and its depository. When it applies, the synonymy is given (again with complete references to the primary sources). Then comes an exhaustive list of all literature records for Turkmenistan, eventually followed by new records, resulting either from the author's own collecting activities in this country, which he visited three times (in 1986, 1989 and 1990) or from data gathered in several museum collections. The distribution in Turkmenistan, flight period and habitat (including altitudinal range) are briefly quoted and for almost each and every taxon a distribution map is presented. In some cases, when judged appropriate, some comments are given, mostly about the taxonomic status. Then comes the Plates section, including 24 colour plates, totalling 1,047 figures, on which most taxa can be located. On the whole they are of a very good quality. With the exception of plates 3 and 24, that show all known Papilionidae as well as some unmistakable species of other families like *Danaus chrysippus, Libythea celtis, Limenitis reducta, Nymphalis polychloros, Vanessa atalanta, V. cardui, Aglais urticae* and *Anaphaeis aurota* only on the upperside, all taxa are figured on the upperside on one plate, followed by their undersides on the next one. The next ten plates show line drawings of male genitalia of selected species-group taxa. On pp. 214–215 is a list of species considered erroneously recorded from Turkmenistan. The book ends with a References list (no less than 298 entries!) and an Index to (genus- and species-group) taxa.

This is the first illustrated guide to the butterfly fauna of Turkmenistan, a fauna of interest to all students of both West-Palaearctic and Central Asian taxa. Indeed, here the southern desert fauna of the Middle East and Iran comes in contact with the Central Asian desert fauna. On the Kopet Dagh mountain range one can find, beside some endemics, several European and Central Asian species flying together. For certain species characteristic for Asia Minor, the Kopet Dagh mountains constitute the extreme eastern limit of their range, while it is also the westernmost outpost of several taxa belonging to the Central Asian and Afghan-Pakistani fauna. Therefore this work is very welcome to every student of these faunas. While the book contains a wealth of information, some important shortcomings have unfortunately to be dealt with as well. To the reviewer, the main one is the inclusion in the main section of no less than 23 species-group taxa (i.e. about 13 %!) that have nothing to do there. The nominal taxa *Spialia geron struvei, Muschampia poggei poggei, Pyrgus carthami carthami, Pelopidas thrax thrax, Pieris bowdeni bowdeni, Satyrium hyrcanica hyrcanica, S. lunulatum lunulatum, Neolycaena iliensis iliensis, Callophrys suaveola suaveola, Tomares callimachus callimachus, Plebeius ferganus ferganus, P. caeruleus caeruleus, Lasiommata maera maera, Hyponephele naricina naricina, H. wagneri wagneri, Hipparchia stulta stulta, Pseudochazara mamurra schahrudensis, Chazara persephone transiens, C. staudingeri staudingeri, Melitaea didyma neera* and *Argynnis adippe adippe* are included solely based on some unconfirmed literature quotations, with no extant collection material known to the author. The inclusion of *Polyommatus elbursicus elbursicus* is based on the misidentification by the author of a specimen of *P. transcaspicus*, figured in a publication by Carbonell and

correctly ascribed to that taxon by that author! *Polyommatus mofidii mofidii* is included solely because of its presence on the Iranian side of the Kopet Dagh! *Pelopidas thrax thrax* is a Palaeotropical species that can only survive in the Western Palaearctic along the Mediterranean and Aegean coast of Turkey and on the Greek island of Sámos: evidently, the quotations by Christoph and Heyne relate to *Eogenes alcides*! It would have been better if the author had, on pp. 214–215, named that section "A list of unconfirmed and erroneous records of species-group taxa for Turkmenistan" and had included all forementioned taxa therein. The "loss" of taxa in the main section could have been compensated for by the inclusion of the butterfly fauna of the Kugitang region (five nominal species-group taxa, cf. p. 215). On the other hand, *Favonius quercus quercus* and *Satyrium acaudatum acaudatum* are included only "conditionally", although unmistakable collection material (which the author figures on plate 8) exists. The nominal taxa *Coenonympha leander transcaspica* and *Satyrus amasinus kyros*, though perhaps described after mislabelled specimens, have their place in this section as their type locality is quoted as from within the boundaries of present-day Turkmenistan. *Colias alfacariensis* is included as "*Colias sareptensis sareptensis*": during a visit to the Museum für Naturkunde der Humboldt-Universität zu Berlin in November 1998, the reviewer has examined the syntypes of the latter taxon and noticed that they are nothing else but yellow *Colias erate* specimens! Some further minor mistakes have been noted as well: for instance, *Pontia callidice* (p. 67) does not occur in the Balkan Peninsula. *Hesperia comma* starts flying only well into July and not in May (p. 50): the relevant data, taken from literature, certainly apply to the nominal taxon listed as "*Ochlodes sylvanus faunus*". An explanation for the choice of that name, considering the current nomenclatural debate, would have been desirable, as it would have been, for instance, for the choice of the subspecies names *Pieris brassicae ottonis, P. napi pseudorapae* and *Aporia crataegi pellucida*. Data on the bionomics of each taxon are very limited. While the English used in the Introduction is quite good, the comments about the nomenclatural status of some taxa are sometimes really poor (e.g. on p. 110; elsewhere read "worn" instead of "overflown", "temperate Asia" instead of "moderate Asia"); the more, typographical errors appear all too often throughout the text. Sometimes, a literature reference was not re-checked thoroughly (e.g. on p. 19: Staudinger (1901: XXX)).
All these details clearly give the impression that this book, for some reason, was hastily edited and published.

Despite all these critical remarks, the author has to be congratulated for this highly informative and comprehensive book, that fills an important gap in our knowledge of the butterfly fauna of this region. No serious student of Palaearctic butterflies should miss it. It is hoped, however, that the minor drawbacks reported in the present review will not be evident anymore in the announced book on the butterflies of Uzbekistan.

Alain Olivier

Maes, Dirk & Van Dyck, Hans: Dagvlinders in Vlaanderen. Ecologie, verspreiding en behoud.
17 × 25 cm, 480 pp., 29 text figures, 32 tables, 124 maps (unnumbered), 50 diagrams (unnumbered), 112 colour photographs (unnumbered), hardback. Published by Stichting Leefmilieu vzw/KBC in association with Instituut voor Natuurbehoud and Vlaamse Vlinderwerkgroep vzw, Antwerpen, 10.IV.1999. ISBN 90-76429-02-2. To be ordered from: Stichting Leefmilieu vzw/KBC, Kipdorp 11, B-2000 Antwerpen. Tel. 0032 3 231.64.48 – fax 0032 3 232.63.98; e-mail: leefmilieu@village.uunet.be. Price: BEF. 1,250.

The butterfly fauna of Northwestern and Central Europe is in a more and more precarious situation. At the same time it is among the best studied invertebrate groups in the world. For nearly each species, we have now rather detailed information on its ecology, biology, status and distribution and over the last decennium a series of books and distribution atlases appeared, dealing with the butterfly faunas of Northwestern Europe in general (the well-known "Ecologische Atlas van de Dagvlinders van Noordwest-Europa" by Fritz A. Bink in 1992), as well as with several countries or regions specifically (the British Isles, the Netherlands, Denmark, Switzerland, Baden-Wurttemberg, Austria, Poland). A book on the butterflies of Germany is in preparation. The present book deals with the butterflies of Flanders (i.e. the northern half of Belgium) and has been written by two professional scientists who work respectively at the Nature Conservation Institute of the Flemish Community and at the University of Antwerp. As a result of hard work over the last decennium, aided by intensive inventarisation and monitoring activities by a working-group of enthusiastic and benevolous collaborators, the Vlaamse Vlinderwerkgroep vzw, the authors have produced the present excellent work. As its subtitle states, the book consists of three main parts: ecology, distribution and conservation.

The book starts, however, with a separate chapter, a general introduction, documenting the scope of the present book and its aims, a history of research on butterflies in Flanders and the Butterfly project *in se*: the data (from collections, literature, field observations, monitoring) and their handling, the resulting distribution maps, rarity formerly and presently, coverage of inventarisation activities. Then comes the first main part. This is a very exhaustive treatise of the various aspects, integrating in a masterly way all data compiled from the growing body of — both foreign and national or regional — publications on various aspects of butterfly bionomics, along with own new data (e.g. as a result of the junior author's research on *Pararge aegeria*). Environmental influences on the occurrence of butterflies are reviewed, weather and climate, including its seasonality, for instance, as well as the responses of butterflies to these, both physiologically (e.g. thermoregulation) and phenologically (adjustments of the flight period of the adult and of the feeding period of the larvae), or in their (micro-)habitat use. Further, adult and larval food are briefly considered, followed by the topics mating (with the various strategies, i.e. perching, patrolling, leks, etc.), egg-laying, larval feeding habits,

ant-associations in Lycaenidae, enemies (predators, parasites and parasitoids, diseases). The relationships and responses of butterflies to the various landscape and vegetation types also receive wide attention, and so does their invaluable role as bioindicators. Their symbolic value is also emphasized in its various aspects (collection or decorative objects, pictural objects in art, on post stamps) as well as their possible role in education and conservation and the large sympathy they enjoy by the larger public. Distribution patterns, mobility and population structure (open vs. closed) are topics that also receive large attention. Methods to study these subjects (inventarisation, MRR, etc.) are also dealt with. Dispersal in its various forms is then treated and the results of various studies on butterfly mobility are considered, along with their potential value in colonisation and gene exchange between populations. A whole chapter is then devoted to population dynamics and the first part ends with another chapter on butterfly populations in fragmented landscapes. The results of fragmentation (habitat loss, edge effects, isolation along with its effect on mobility) are reviewed, after which the metapopulation concept and its great significance for conservation are emphasized and, finally, the role of barriers and corridors in the modern agricultural landscape.

The second part, dealing with the distribution of butterflies in Flanders, is by far the largest one. First, a review of the butterflies of Flanders is presented: they are divided in several categories, each of which is briefly defined: indigenous, migrant, vagrant, stray, adventive. The scientific (latin names) and their order of presentation follow the well-known "The Lepidoptera of Europe. A distributional checklist", edited by Karsholt & Razowski (1996). Then comes a checklist of the 88 butterfly species that have been observed in Flanders so far. Their scientific name is followed by their vernacular name. Of these taxa, 64 are indigenous, 4 are regular migrants, 19 are strays and one (*Polyommatus damon*) is considered adventive. 17 more taxa have further been reported from Flanders, either dubiously (no extant collection specimens exist) or, most probably, as a result of wrong identification: they are briefly reviewed but not considered anymore in the remainder of the book. The detailed treatment of each single species makes up the bulk of the book (pp. 152–366). Especially the indigenous species and the regular migrants are dealt with most comprehensively. Their vernacular and latin (scientific) name is presented, followed by the most commonly used (both vernacular and scientific) synonyms. Then their ecology is dealt with, comprising a brief characterization of the habitat, flight period, mobility and a treatise on their biology and larval host plants. After a brief discussion of its range in Europe, the distribution of each species in Flanders is treated in detail, aided by a distribution map before 1991 and — when the butterfly is not extinct yet — since 1991. Changes in the distribution during the 20th Century are illustrated by means of a diagram, hence it is easy to discern whether the species has progressed or declined. A separate section deals with its legal conservation status in Flanders, in Belgium and in Europe, the specific threats and the suggested conservation measures to maintain or improve its status. For extinct and Red List species, the possible relevance of re-introduction

is briefly discussed. Additional literature references applying to each single species are mentioned as a last item. The adult of each of these taxa is figured by means of a beautiful colour photograph of a living specimen, often in either basking or resting position. The strays and adventives are dealt with more briefly and only one is figured in the relevant section. The three last chapters of the second part deal respectively with an analysis of the status of the butterfly fauna of Flanders (changes in species number and composition, both generally and in relation to each of the main ecological regions and habitat types, rarity classes, a Red List of the butterflies of Flanders), the reasons of the general decline of this fauna (catching and collecting, habitat fragmentation and loss, fertilizers, dessication, acidification, herbicides and pesticides, climat change) and a brief mention of the status of the butterfly faunas in Wallonia (southern half of Belgium), in Belgium, in The Netherlands, in Germany, in Great Britain, in Europe and worldwide. A checklist of the butterflies of Belgium can also be found in this section. The situation of the butterfly fauna of Flanders is alarming: 16 species have become extinct during the 20th Century, 17 species have experienced a significant decline, 20 species have more or less maintained a status quo and 11 speces have progressed. Species that used to be rare have become very rare or extinct, while species that used to be common have become very common ("banalization" of the fauna). This trend also applies to the butterfly fauna of the British isles or to the herpetofauna of Flanders.

The third and last part deals with conservation, with an emphasis on strategies for the conservation and restoration of the butterfly fauna of Flanders, including the use and application of the Red List, the role of governmental bodies, legislation and action plans, and priorities and education. This extremely well-documented book ends with a very comprehensive references list (no less than 828 entries!), an appendix listing all contributors to the project as well as the consulted collections and literary sources, an appendix listing the vernacular, the scientific and the English names of the butterfly species of Flanders, a glossary, an index and a brief presentation of the conservation bodies, both governmental and non-governmental.

The use of the Dutch language, fully justified in the present context, as it is conceived for use mainly by a Flemish readership and governmental and conservation bodies, will of necessity somewhat restrict the international interest of this excellent work and the reviewer would have preferred the inclusion of a checklist of all plant species, of which only the vernacular name is used throughout, with both the vernacular and scientific name. Nevertheless, it deserves to be distributed more widely than in Flanders and The Netherlands alone and people acquainted with German or any Scandinavian language should not experience too many difficulties in reading it. It is very well readable, very well structured and hence methodologically also an example. It is to be hoped that the existence of such a tool will now serve as a stimulus for the implementation of a real conservation policy and, ultimately, an improvement of the quality of the environment in which we live ourselves,

both in Flanders and abroad. Nature conservators, sensibilized landowners, decisionmakers, as well as all lepidopterists and nature lovers should read this book.

Alain OLIVIER

Naumann, Clas M., Tarmann, Gerhard M. & Tremewan, W. Gerald: The Western Palaearctic Zygaenidae (Lepidoptera).
17 × 24 cm, 304 pp., 178 text figures, 4 tables, 12 colour plates (with 375 figures), 115 maps (unnumbered), hardback. Published by Apollo Books, Stenstrup, January 1999. ISBN 87-88757-15-3. To be ordered from: Apollo Books Aps., Kirkeby Sand 19, DK-5771 Stenstrup, Denmark. Tel. 0045 62 26.37.37 – fax 0045 62 26.37.80. Price: DK 600 excl. postage.

This long-awaited book is the condensed result of a lifelong study of the western Palaearctic representatives of this fascinating family by three of the foremost specialists on the group. It is beautifully introduced by a nice foreword by Miriam Rothschild, followed by one by the authors. The general part (pp. 13–95) treats topics such as systematics and phylogeny, Zygaenid life cycles, structures and functions (including a generalized description of larval morphology and chaetotaxy, pupae and cocoons, adult internal morphology, senses and orientation, nutrition), genetics and individual variation (with special attention to some phenomena like polymorphism in *Zygaena*), zoogeography (geographical variation, distribution patterns), fossil records, ecology and behaviour (habitat preferences, host plants, cyanogenesis, defensive and reproductive biology, flower-insect relationships, reproductive strategies, mimicry and behaviour, predation and diapause, parasitoids), the role of Zygaenids as indicator species both in dispersal studies and in conservation, breeding, collecting techniques and an interesting review of history of research on the Zygaenidae, a list of vernacular names of Zygaenidae and a selected references list (96 entries). This general part is highly interesting throughout and some parts, like e.g. polymorphism, cyanogenesis, reproductive strategies and diapause, were most fascinating reading to the reviewer. First class black-and-white illustrations (including a.o. line drawings and remarkable SEM-photographs of endo- and exomorphological structures, and portrets of some famous deceased authorities on Zygaenidae) contribute much to the high quality of the whole.

The systematic part (pp. 97–290) starts with a checklist of the western Palaearctic Zygaenidae (at species level). The area covered here includes the whole of Europe with the Ural Mts., North Africa (the Maghreb countries plus the mediterranean coastal areas of Libya and Egypt including the Sinai), Jordan, Israel, Lebanon, Syria, the whole of Turkey, Transcaucasia and the Caucasus. Iran and Iraq however are not, or only marginally, considered. After a brief diagnosis of the family Zygaenidae and a key to its subfamilies, the first subfamily to be treated in detail is the Procridinae: after a characterization and diagnosis and a key to its genera, with a diagnosis of the relevant genus to which it belongs, each species is treated in detail. After

its scientific name, author(s) and year of description and a reference to the plate on which the imago is figured, a brief description follows in the following order: forewing length — male — male genitalia (with reference to the text figure on which they are depicted) — female — female genitalia (with reference to the text figure on which they are depicted) — similar species (with their resp. diagnostic features) — individual variation — geographical variation (with a list of subspecies (including a reference to the plate on which the imago is figured), their characteristics and distribution) — distribution — ecology — behaviour — egg — larva — larval foodplants — pupa and cocoon. For each species, a distribution map is presented. Separate identification keys are presented for western Palaearctic *Rhagades*, male *Jordanita*, female *Jordanita*, male *Adscita* (*Adscita)* and female *Adscita (Adscita)*. On pp. 160–185, excellent line drawings of resp. the male and female genitalia of all the species are presented. The subfamily Chalcosiinae, represented in the western Palaearctic by only one genus (*Aglaope*) and two species (*infausta* and *labasi*), is treated similarly but without illustration of the genitalia. The subfamily Zygaeninae, consisting of one genus (*Zygaena*) with three subgenera (*Mesembrynus, Agrumenia* and *Zygaena*), each with a brief diagnosis, and one general key to its western Palaearctic species, is treated similarly, but genitalia are (partly) figured only occasionally for identification purposes, in critical cases (e.g. *Zygaena purpuralis* group, *Z. transalpina* group, *Z. filipendulae* group). Colour plates 1 to 6 show set specimens of all species of Procridinae (1 and 2), Chalcosiinae (2) and Zygaeninae (3 to 6), plates 7 and 8 show living specimens of several taxa, either in resting posture or in copula, plate 9 shows some interesting behavioural features (e.g. extruded pheromone gland of a 'calling' female *Zygaena*, extruded male coremata of a *Zygaena*) as well as some parasitoids and predators, plate 10 shows some larvae and one cocoon and, finally, plates 11 and 12 offer a selection of habitats. The book ends with an appendix on the recently described *Jordanita (Jordanita) fazekasi* and an index.

With the present work, it should be possible to identify without too many difficulties, each and every species of (adult) western Palaearctic Zygaenid. The only serious criticism the reviewer would make, is the total absence of any reference to primary sources (both type specimens and literary source). Any lepidopterist, also the non-specialist, with any interest in this beautiful and, in more than one respect, highly interestig butterfly family, can simply not do without the present work. The authors deserve our warmest congratulations.

Alain OLIVIER

Efetov, Konstantin A. & Tarmann, Gerhard M.: Forester Moths. The genera *Theresimima* Strand, 1917, *Rhagades* Wallengren, 1863, *Jordanita* Verity, 1946, and *Adscita* Retzius, 1783 (Lepidoptera: Zygaenidae, Procridinae).
17 × 24 cm, 192 pp., 415 text figures (241 in colour, on 12 unnumbered plates), 4 tables, hardback. Published by Apollo Books, Stenstrup, 1999. ISBN

87-88757-23-4. To be ordered from: Apollo Books Aps., Kirkeby Sand 19, DK-5771 Stenstrup, Denmark. Tel. 0045 62 26.37.37 – fax 0045 62 26.37.80. Price: DK 460 excl. postage.

A few months after the book on western Palaearctic Zygaenidae by Naumann, Tarmann & Tremewan, Apollo Books have published the present work which, as will be shown, is largely complementary to the first-mentioned one. It treats all the 63 Procridinae species occurring in Europe, North Africa and the western and central parts of Asia, i.e. the western and central Palaearctic.

After an introduction, followed by a "definition" of the Procridinae, some significant diagnostic characters of the Procridinae are discussed, i.e. chaetotaxy of first instar larvae, chromosome numbers of several species belonging to different (sub-)genera and some peculiarities of both the proboscis and the fore tibia, after which some character combinations are treated. Subsequently, possible phylogenetic relationships are discussed, with a separate heading for *Theresimima, Rhagades* and *Jordanita* and *Adscita*. Next, a checklist of species-group taxa (species, subspecies and their synonyms, some of these newly) in these genera is presented. Then comes the systematic catalogue. For each species-group taxon, the genus and species name, followed by the author(s) and year of description, is quoted, immediately followed by a reference to the different figures on which the taxon is figured (male and female genitalia, adult male and female, early stages). Then a reference to the primary sources is stated in full, i.e. original combination, publication, depository of type (holotype or lectotype). Synonyms are listed and the type locality is documented. When a lectotype is newly designated (for 17 taxa in the present work), labels are listed fully. The range and host plants are also mentioned, the latter with reference to the literary source when known already. Two new subgenera, *Tremewania* and *Procrita*, are described. A next chapter consists of several keys to genera, to subgenera and to species, sometimes including different keys to males and females, with figures of features such as wing venation, forelegs, distal end of male antennae, forewing scales and pupae. A separate chapter consists only of (excellent) line drawings of resp. male and female genitalia, executed by the late Vyacheslav V. Kislovsky (1974–1998), who also produced the majority of the other line drawings. In a next chapter, the immatures and life histories of six species of *Jordanita* and *Adscita* are described. Then comes a series of new records of parasitoids, followed by the acknowledgements section. After this, colour illustrations of adult moths, early stages, host plants and biotopes are presented. Five colour plates (figs. 175–307) show paintings of set specimens, followed by seven colour plates consisting of photographs of lectotypes, early stages, adults and biotopes. The book ends with a comprehensive list of references (344 entries) and indices, resp. of Lepidoptera names, authors and larval host plants.

The present book is an attempt to summarize new data and to enable the identification of all known species of the group. No distribution maps are included, but in the Introduction it is stated that a distribution atlas is planned at a later date. Data on nomenclature and taxonomy, along with a larger

geographic coverage and hence additional species, make this book a welcome addition to the work of Naumann, Tarmann & Tremewan. For students of Zygaenidae in general, and of Procridinae specifically, this is an absolute must.

Alain Olivier

Kristensen, N. P. (ed.): Lepidoptera, Moths and Butterflies. Volume 1: Evolution, Systematics, and Biogeography. Part 35 in M. Fischer (Ed.): Handbook of Zoology. Volume IV Arthropoda: Insecta.
21 × 29.7 cm, 494 p., numerous figures, hardback. Published by de Gruyter, Berlin, New York, 1999. ISBN 3-11-015704-7. To be ordered from: Walter de Gruyter & Co., Genthiner Str. 13, P.O. Box 303421, D-10728, Berlin, or from Walter de Gruyter Inc., 200 Saw Mill River Road, Hawthorne, NY 10532, USA. Price: DEM 398 plus postage.

While it was still possible to write treatises on insect groups in the past (e.g. the Diptera volume in 1972 by W. Hennig) in this ambitious series "Handbook of Zoology" founded by W. Kükenthal, this is no longer possible in such large insect orders as the Lepidoptera. Furthermore, the editorial principles and standards have changed considerably to ensure that the series can continue to fulfill its intended role in the biological reference literature. Therefore, the editor has gathered a team of 29 specialists, who are responsible for the texts of the separate chapters. Much original research work was carried out to put the present state of knowledge at the most recent level and many texts which were completed for the first deadline in 1997 have been changed since that year in order to reflect the most recent state of the art. Many contributions had to be shortened because of publisher's demands and some even have been published elsewhere in full length while the present book just contains a summary of these.

Two Lepidoptera volumes are planned. The plans for a third volume on ecology and behaviour were abandoned because it was considered more appropriate to publish such a volume not focusing on the order of Lepidoptera alone. Nevertheless, several topics on Lepidopteran ecology and behaviour are included in the present volume and in the forthcoming second volume at relevant places. This first volume concentrates on systematics, evolution and biogeography, while in the second one the emphasis will be put on morphology and physiology. The present volume consists of 21 chapters.

Chapter 1. "Historical Introduction". Because Lepidoptera are very conspicuous insects, they have been the subject of many publications before the Linnean landmark of 1758. In this chapter a very brief outline is given of these pre-Linnean publications, as well as of those in the Linnean period, while the emphasis lays on the 19th Century achievements in Lepidopteran studies.
Chapter 2. "Phylogeny and Palaeontology". The monophyly of the Lepidoptera has been established by an impressive series of synapomorphies, separating this order from its sister group Trichoptera, the two groups forming the higher

rank taxon Amphiesmenoptera. This chapter first treats the ground plan and intrinsic phylogeny of the Lepidoptera. Subsequently the palaeontological contributions to the knowledge of Lepidoptera evolution are surveyed. A tentative phylogenetic tree of all extant superfamilies is given, indicating the species richness of all groups. The chapter further contains pictures of fossil Lepidoptera, preserved in amber or stone.

Chapter 3. "Classification and Keys to Higher Taxa". The systematic chapters in this Handbook are all written on the basis of "Henigian" phylogenetic principles. Therefore, all taxa which are identified as likely poly- or paraphyletic have been rejected, or they are accepted merely as preliminary groupings, pending further analysis. Many disagreements were encountered during the preparations of the texts for those systematic chapters, many authors having different views on the ways in which phylogenetic study results should be transformed into a written classification. While in several publications the Linnean categories have been discussed and rejected as useful tools for present-day classifications, they have been retained in the present book. This chapter contains a key to identify the different superfamilies, using adult characters, and a key to families, using larval characters.

Chapters 4–19. In these chapters a systematic treatment is given of all extinct and extant Lepidoptera. The chapters are divided as follows: The Non-Glossatan Moths (Micropterigoidea, Agathiphagoidea, and Heterobathmoidea), The Homoneuros Glossata (Eriocranioidea, Acanthopteroctetoidea, Lophocoronoidea, Neopseustoidea, Mnesarchaeoidea, and Hepialoidea), The Monotrysian Heteroneura (Nepticuloidea, Incurvarioidea, Palaephatoidea, and Tischerioidea), The Tineoidea and Gracillarioidea, The Yponomeutoidea, The Gelechioidea, The Zygaenoidea, The Cossoid/Sesioid Assemblage (Sesioidea and Cossoidea), The Tortricoidea, The Smaller Microlepidoptera-Grade Superfamilies (Galaticoidea, Simaethistoidea, Choreutoidea, Urodoidea, Chreckensteinoidea, Epermenioidea, Alucitoidea, Pterophoroidea, Copromorphoidea, Immoidea, Hyblaeoidea, Thyridoidea, and Whalleyanoidea), The Pyraloidea, The Axoidea and Calliduloidea, The Butterflies: Hedyloidea, Hesperioidea and Papilionoidea, The Drepanoid/Geometrid Assemblage (Drepanoidea and Geometroidea), The Bombycoidea and Their Relatives (Mimallonoidea, Lasiocampoidea, and Bombycoidea), and The Noctuoidea. All these chapters contain information on their morphology and systematics and are well illustrated with diagrams of morphological structures, pictures of set adult specimens and caterpillars. Also still unresolved problems are mentioned throughout. Keys to families and subfamilies are included where appropriate. Every chapter ends with a reference list to further reading.

Chapter 20. "Evolution of Larval Food Preferences in Lepidoptera". Because the majority of lepidopteran larvae live at the expense of living seed plants, it has been thought that evolution within the Lepidoptera is closely related to that of plants. On the other hand, non-phytophagous habits are found primarily in basal lineages of Lepidoptera, suggesting that these might have had non-phytophagous ancestors. In this chapter the evidence for and against these contrasting views of feeding habit evolution are summarised.

Chapter 21. "Biogeography of the Lepidoptera". The combination of high diversity in Lepidoptera (being one of the four major insect groups) and a detailed information on geographical coverage available in numerous museum collections, mean that Lepidoptera are very well suited as a subject of biogeographical studies. It is observed indeed that Lepidoptera studies are prominent in many areas of biogeographical research. This chapter gives an account of the past studies in this area and also puts forward some hypothesis emerged from recent discussions amongst biogeographers.

The book ends with an index of scientific Lepidoptera names. It is extremely well edited, and it contains a wealth of information in condensed form, brought together by the contemporary world's leading specialists. It is a pity, however, that in a present-day publication of such an importance no colour illustrations are used to depict such colourful insects as the Lepidoptera, especially when one takes into account its rather high price. Because of this economical barrier, many of the relevant information contained in this book will not find its way to the broad public of serious students of Lepidoptera who have not easy access to university or museum libraries. It is hoped, however, that the second volume will be published in due course.

Willy De Prins

Scoble, Malcolm J. (Herausgeber): Geometrid Moths of the World. A Catalogue.

21 × 29 cm, 1400 S., hardback, 2 Bände mit einer CD-ROM. CSIRO Publishing und — für Europa — Apollo Books, 1999. ISBN 87-88757-29-3. Bestellungen an: Apollo Books Aps., Kirkeby Sand 19, DK-5771 Stenstrup, Denmark. Preis: DKK 1.990/US$ 295, ohne Versand.

Angesichts der rapide fortschreitenden Bedrohung der Biodiversität durch Umweltschäden versteht sich der Katalog als ein Schritt in Richtung auf die Erarbeitung einer "Passagierliste" für unser Raumschiff Erde. Die Zielgruppe für einen verläßlichen Katalog aller bekannten Arten der Geometriden, die mit den Pyraliden und den Noctuiden die drei größten Schmetterlingsgruppen der Welt darstellen, ist daher auch umfassend: "Entomologen, Systematiker, Evolutionsbiologen, Ökologen".

Ausgehend von dem legendären "card index" im Natural History Museum, London, will der Katalog die — teilweise noch unveröffentlichte — taxonomische Information zu allen nomenklatorisch verfügbaren (im Sinne des Code von 1985) Namen der Geometridenarten der Welt zusammenfassen und rasch und einfach zugänglich machen. Zu diesem Zweck sind ca. 35.000 Artnamen in ihrer originalen Schreibweise (was zutreffend begründet wird) alphabetisch den — ebenfalls alphabetisch gereihten — Gattungen zugeordnet und mit Autor, Jahr, Fundstelle der Urbeschreibung, ursprünglichem Genus, Typenverbleib und Angaben zu Typus/Typen einschließlich Typengeographie und — soweit bekannt — schließlich auch den Futterpflanzen aufgelistet.

Synonyme und Homonyme sind bei den validen Artnamen angegeben. Bei den Gattungsnamen werden Autor, Jahr, Fundstelle und die Subfamilie genannt. Diese Fülle an Daten läßt wohl kaum einen Wunsch offen.

Stichprobenartige Recherchen ergaben, daß der Katalog tatsächlich vollständig ist: Man kann getrost davon ausgehen, daß mehr als 99,9 % der bis 1998 publizierten, verfügbaren Namen enthalten sind! In beinahe täglicher Benutzung des Kataloges über zwei Monate hinweg konnten nur in den seltensten Fällen Schreibfehler ausgemacht werden, z.B. *Photoscotosia "elagantissima"* (S. 746 und Index) statt *"elegantissima"*!

Welchem hohen Zuverlässigkeitsanspruch der Katalog genügt, läßt sich schon daran ermessen, daß für alle ca. 35.000 Artnamen die Urbeschreibungen eingesehen wurden. Das heißt nicht, daß Experten bei gründlicher Nachsuche nicht noch einzelne Fehler entdecken könnten. So ist *Eupithecia luteostrigata deverrata* Chrétien (S. 359) synonym und homonym mit *Eupithecia deverrata* Dietze (S. 338), da sich beide Namen auf Material derselben Zucht stützen (Herbulot pers. Mitt.). Die Arten *obliqua* B.-Bak., *sudanica* Herb., *viridans* Prt. und *xanthostephana* Prt. sind in die Gattung *Thelycera* (S. 933) einzureihen, nicht in *Mixocera* (S. 612) wie schon Prout (in Seitz 16 (1930): 45) bemerkte.

Es handelt sich hier aber um seltene Ausnahmen, was bei einem solchen Monumentalwerk freilich insgesamt nicht ins Gewicht fällt. In welchen Intervallen und in welcher Form Berichtigungen und künftige Ergänzungen nachgereicht werden, ist wohl noch nicht entschieden.

Daß die Fundstellen zitierfähig wiedergegeben sind und die geographischen Angaben aktuell ergänzt wurden, ist praxisfreundlich. Der Benutzer wird es den Verlegern außerdem sehr danken, daß ein vollständiger Namensindex jedem der beiden Bände beigegeben wurde. Auf der CD-ROM finden sich eine Liste der validen Namen mit Autor (ohne Jahr, ohne aktuelle oder ursprüngliche Gattung) sowie 59 attraktive Farbbilder von Geometriden.

Verdienstvollerweise enthält der 2. Band einen Anhang mit einer systematischen Reihung der Genera entsprechend der Anordnung in der weltweiten Sammlung des Natural History Museums, London. Dies läßt auf einen weiteren Effekt dieses meisterlichen Katalogwerkes in der Sammlungspraxis hoffen: Fast alle großen Museen haben mehr oder weniger bedeutende Mengen an Geometriden außerpaläarktischer Herkunft, die aber wegen der nicht vollendeten Bearbeitung im Lepidopterorum Catalogus und im "Seitz" nur in seltenen Fällen systematisch "aufgestellt" wurden. Mit dem Katalog haben die Kuratoren endlich eine Grundlage für die Zu- und Einordnung ihrer Bestände, die dann — ganz im Sinne der Katalogverfasser — der Bearbeitung und Forschung zugänglicher werden als bisher. Packen Sie's an!

Der Katalog setzt auf höchstem Niveau Maßstäbe für Inhalt und Aufbereitung globaler taxonomischer Information und ist tatsächlich, wie es im Vorwort heißt, "a benchmark". Die Leistung des namhaften Bearbeiterteams (Mark

S. Parsons, Martin R. Honey, Linda M. Pitkin, Brian R. Pitkin) um Dr. Malcolm J. Scoble, den Geometridenspezialisten im Natural History Museum, ist aller Anerkennung wert. Kritisches? Allenfalls, daß ein Werk dieses Schlages, das man mit so viel Gewinn und Sympathie zur Hand nimmt, schon einen farbenfrohen Einband verdient hätte!

Axel Hausmann & *Manfred* Sommerer

Huemer, Peter & Karsholt, Ole: Microlepidoptera of Europe, Volume 3, Gelechiidae I (Gelechiinae: Teleiodini, Gelechiini).
24 × 17 cm, 356 pp., 47 text figures, 14 colour plates (depicting 321 specimens), 114 black-and-white plates (depicting 151 male genitalia and 151 female genitalia), hardback. Published by Apollo Books, Stenstrup, January 1999. ISBN 87-88757-15-3. To be ordered from: Apollo Books Aps., Kirkeby Sand 19, DK-5771 Stenstrup, Denmark. Tel. 0045 62 26.37.37 – fax 0045 62 26.37.80. Price: DK 500 excl. postage.

While some families of the so-called Microlepidoptera are treated in numerous publications, others hardly receive any attention of the authors. Descriptions of new taxa, records on the distribution, flight period and biology are scattered all over the entomological literature. This applies very well to the Gelechiidae. Apart from some taxonomic treatments of single genera (e. g. *Mirificarma, Teleiopsis*), no general review of the family as a whole has ever been published for the European fauna. The main reasons for this may be the inconspicuous external appearance of the adults and the difficulties encountered while identifying the specimens.

This book aims to fill part of this gap and will be followed (soon?) by three more volumes treating part of the Gelechiidae. In this first part 151 species are recognised, belonging to the tribes Teleiodini and Gelechiini. Ten new species are described: *Stenolechiodes macrolepiellus* (Greece), *Teleiodes albidorsella* (Spain), *Carpatolechia intermediella* (Spain), *Pseudotelphusa occidentella* (Morocco, Portugal, Spain, southern France), *Xenolechia pseudovulgella* (Greece, Turkey), *Xenolechia lindae* (Greece), *Altenia elsneriella* (Croatia, Macedonia, Greece, Cyprus), *Mirificarma pederskoui* (Spain), *Aroga balcanicola* (Macedonia, Greece, Iran), and *Neofriseria baungaardiella* (Greece, Spain). Sixteen new synonymies are established, while two taxa are recalled from synonymy. Sixteen new combinations are introduced. Lectotypes are designated for fifteen taxa.

The book starts with introductory chapters about collecting methods, genitalia preparation, the morphology of the Gelechiidae and their systematics and classification, and a key to the subfamilies of European Gelechiidae. The systematic part starts with a key to the European genera of Teleiodini and Gelechiini, based on male and female genitalial structures, and a check-list of the species treated in this part with full synonymy. The same complete synonymy can be found in the systematic treatment of every species, but here

including the original combination and with complete references to the source of description. The text of each species furthermore includes a short diagnosis, some words about the variation and reference to similar species with which the taxon can be confused. There are short descriptions of male and female genitalia and data on the distribution in Europe, the biology (in many cases only including a reference to the larval food plant, or lacking at all!), and the flight period. In most cases also a short paragraph is added containing additional remarks on taxonomy, synonymy and so on. The text is accompanied by 47 text-figures, mainly illustrating the eighth abdominal segment of the male, which in many cases gives good taxonomic characters. This part of the book concludes with a taxon of which the systematic position is unclear, and with a distribution catalogue similar to that of the recently published account of the European Lepidoptera.

All species are illustrated on 14 colour plates depicting 321 neatly set specimens, in most cases allowing identification without further examination of morphological characters, also because the specimens are enlarged (the exact scale is missing). These plates are of excellent quality and printed with much care. Because the species are numbered throughout the book and these numbers are mentioned under each figure and in the accompanying text about the origin and whereabouts of the specimens, it is very easy to use these plates in combination with the relevant parts in the main text and with the corresponding plates of male and female genitalia. The latter follow immediately after the colour plates and contain photographs of the genitalia preparations. Also these plates are of excellent quality and easy to use.

The book ends with a list of references and three alphabetical indices: to the entomological genus names, to the entomological species names and to the host plants. This very well edited and produced book will be welcomed by many European students of Microlepidoptera who finally have a tool to identify part of their Gelechiidae. It is hoped that the next three volumes will follow soon.

Willy De Prins

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Instructions for authors

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Papers submitted to *Nota lepidopterologica* should be original contributions to any aspect of lepidopterology. Publication languages are English, German and French. All manuscripts will be reviewed by a board of assistant editors and by at least two appropriate referees. The editors reserve the right to make textual corrections that do not alter the author's meaning.

The manuscript should be submitted in triplicate and on a PC-compatible (not Macintosh) disk. **Please do not send registered mail!** The papers should be accompanied by a summary not exceeding 200 words. *For acceptable style, format and layout please examine recent issues of the journal.* Latin names of genera and species should be underlined or *italicised*. The first mention of any living organism must include the full scientific name with the author and the year of publication, but thereafter the author and date can be omitted and the generic name abbreviated. Male and female symbols have to be coded as @ and # respectively. Geographic and other names in languages where other than Latin characters are used (e. g. Armenian, Chinese, Georgian, Greek, Russian, Ukrainian etc.) should be given in transliteration transcription (not translation!). Summary, tables, footnotes, the list of figure legends and references must be on separate sheets. The title of the paper should be informative and concise. The name and full postal (and e-mail if available) address of the author(s) to whom all correspondence should be addressed should be given on the first page.

The authors should strictly follow provisions of the current edition of the *International Code of Zoological Nomenclature*. New taxa must be distinguished from related taxa (diagnosis, key). The abbreviations **gen. n., sp. n., syn. n., comb. n.** should be used to distinguish all new taxa, new synonymies and new combinations. In describing new genus group taxa, the nominal type-species must be designated in its original combination and with reference to the original description immediately after the new name. In describing new species group taxa, one specimen must be designated as the holotype; other specimens mentioned in the original description and included into the type series are to be designated as paratypes — all immediately after the name. The complete data of the holotype and paratypes, and the institutions in which they are deposited (abbreviated as explained in the introductory section), must be recorded in the original description as follows:

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Higgins, L. G., 1950. A descriptive catalogue of the Palaearctic *Euphydryas* (Lepidoptera: Rhopalocera). — *Trans.R.ent.Soc.Lond.* 101: 435–489, figs. 1–44, 7 maps.

Higgins, L. G. & Riley, N. D., 1980. A field guide to the butterflies of Britain and Europe. 4th ed. — Collins, London. 384 p., 63 pls.

Staudinger, O., 1901. Famil. Papilionidae – Hepialidae. *In*: Staudinger, O. & Rebel, H. Catalog der Lepidopteren des palaearctischen Faunengebietes. 3. Aufl. — Friedländer & Sohn, Berlin. XXX+411 p. (Tagfalter p. 1—97).

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